Forest Insect and Disease Conditions British Columbia and Yukon - 1991

C.S. Wood and G.A. Van Sickle

Pacific and Yukon Region — Information Report BC-X-334

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The Pacific Forestry Centre is one of six regional and two national establishments of Forestry Canada. Situated in Victoria with a district office in Prince George, the Pacific Forestry Centre cooperates with other government agencies, the forestry industry, and educational institutions to promote the wise management of the forest resources of British Columbia and the Yukon.

The Pacific Forestry Centre undertakes research in response to the needs of the various managers of the forest resource. The results of this research are distributed in the form of scientific and technical reports and other publications.

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Abstract

This summary of forest pest conditions in British Columbia and the Yukon Territory in 1991 highlights pests that are or may become major forest management problems. It was compiled from field reports and other records of eleven Forest Insect and Disease Survey rangers with contributions from the forest industry, researchers, and agencies. The status and impact of more than 45 major forest pests are described and some forecasts are made for 1992.

Résumé

Ce résumé de l'état des insectes et des maladies des arbres en Colombie-Britannique et au Yukon en 1991 donne les grandes lignes de ce que sont ou pourraient être les grands problèmes d'amenagement forestier. Il a été compilé a partir de rapports et autres relevés effectués sur le terrain par les onze forestiers du Relevé des insectes et des maladies des arbres et des données fournies par l'industrie forestière et des chercheurs et des organismes oeuvrant dans ce domaine. Il décrit l'état et l'impact de plus de 45 insectes et maladies des arbres d'importance et présente certaines prévisions pour 1992.

Introduction

The Forest Insect and Disease Survey (FIDS) of Forestry Canada is responsible for producing an annual national overview of important forest pest conditions and their implications. In the Pacific and Yukon Region, surveys to detect and monitor important forest insects and diseases and environmental factors are conducted. Additionally, surveys and records are maintained in support of quarantine programs, forest research projects, and insect collections and herbaria. Surveys are conducted with the cooperation of the British Columbia Forest Service, the forest industry, other federal and provincial agencies, municipalities, educational centers, and research programs at the Pacific Forestry Centre and other Forestry Canada centres across Canada.

This regional report reviews the status and impact of major forest insects and diseases and the effects of environmental factors on coniferous and broadleaf forests in British Columbia and the Yukon Territory in 1991. Damage trends and expansion of infestations can be determined by comparison to previous years' reports.

The subjective terms 'light', 'moderate', and 'severe' are used throughout this report to describe levels of tree defoliation; these are defined as 1 to 25%, 26 to 65%, and more than 65% defoliated, respectively.

The report is compiled from information obtained largely from field observations and records collected by 11 FIDS rangers during their field assignments from May to October in six provincial forest regions and the Yukon Territory. More detailed information on the status of forest pests is available in regional reports compiled by the following rangers:

Cariboo	- Bob Erickson and Bob Ferris
Kamloops	- Peter Koot and Janice Hodge
Nelson	- Leo Unger and Alan Stewart
Prince George	- Nick Humphreys and Bob Ferris
Prince Rupert	- Rod Garbutt and John Vallentgoed
Vancouver	- Rod Turnquist and Dennis Clarke
Yukon Territory	- Rod Garbutt

Other staff of the Forest Insect and Disease Survey (FIDS) project in 1991 were:

Allan Van Sickle	- FIDS Head
Colin Wood	- Chief Ranger
Joan Strobbe	- Secretary
Lee Humble	- Entomologist, insectary and collection
Bob Duncan	- Biologist, insectary diagnostics
Jane Seed	- Technician, insectary rearing and data base
Brenda Callan	- Mycologist, diagnostics and herbarium collection
Daphyne Lowe	- Technician, herbarium

Summary

This summary is of pests that were most prominent in the Pacific and Yukon Region in 1991 and most likely to be of interest and concern to the forest community. Equally significant in terms of losses but not reported in detail are several forest diseases such as root rots, stem rusts, cankers, decays, and dwarf mistletoes. These are perennial and, once established, they fluctuate little from year to year, so they are not surveyed on an annual basis.

The most noteworthy changes in the status of major forest pests in 1991 included population increases of **western spruce budworm**, **Douglas-fir tussock moth**, **western hemlock looper**, and **gray spruce looper** in the interior which resulted in defoliation of coniferous hosts over widespread areas. The Asian biotype (race) of **gypsy moth** was also recorded for the first time in the region. Severe infection of conifers and deciduous hosts by **foliar diseases** increased for the second consecutive year, particularly in the southern part of the province, due to above-normal rainfall in the spring. Some forest insect populations were delayed slightly but most were largely unaffected by climatic factors this year.

Mountain pine beetle was again the most damaging forest pest in British Columbia in 1991 with an estimated 1.95 million m^3 of mature pine killed in more than 9065 infestations which covered about 49 600 ha in six regions. Infestations increased overall, particularly in the Kamloops Region, and are forecast to continue in 1992. **Western pine beetle**, **red turpentine beetle**, **lodgepole pine beetle**, and **ambrosia beetle** were less common than in the three previous years, and **pine engraver beetle** populations remained at low levels for the fourth year. **Pinewood nematode** remains very rare and is present only in a few individual predisposed trees at widely scattered locations. A cooperative study was initiated to investigate control of the nematode and its vector by heat treatment. **Pine needle sheathminer** populations again defoliated lodgepole pine regeneration in the southern interior, sometimes in association with western spruce budworm; however, sheathminer populations collapsed in southwest coastal areas after five years of infestation. Populations of a **pine sawfly** in the Vancouver and Prince Rupert regions collapsed following up to two consecutive years of significant defoliation. Discoloration of year-old and older needles by **pine needle diseases** was again common throughout the interior, for the fifth consecutive year in some areas. **European pine shoot moth** remains established in ornamental pines in urban areas in southwest coastal areas and the Okanagan Valley. The few shoots of plantation Douglas-fir found infested for the first time in North America in 1989 and re-infested in 1990 were treated and no further infested shoots were found. **Scleroderris canker** has been found on native pines in British Columbia only at four locations prior to 1974, but has not been found since.

Douglas-fir and some lodgepole pine were defoliated by **western spruce budworm** over more than 395 000 ha in more than 800 separate infestations in parts of three forest regions, more than double the area infested in 1990. Most of the increase was in the Kamloops Region. Increased numbers of egg masses indicate that severe defoliation will occur in 1992 in most stands defoliated in 1991. Patches of forest totaling 135 ha in the Kamloops Region were defoliated for the first time since 1984 by increased numbers of **Douglas-fir tussock moth**; this pest also defoliated groups of trees in the Vancouver Region for the second year. Ornamental trees in urban Kamloops and Okanagan communities were defoliated for the fourth consecutive year. Increased numbers of adults in pheromone traps and egg masses indicate the potential for increased defoliation in both regions in 1992. Mortality of mature Douglas-fir by **Douglas-fir beetle** increased for the fourth year to more than 3160 groups of trees totaling about 3865 ha in parts of six forest regions, and is expected to continue in 1992. Douglas-fir were defoliated by **western false hemlock looper** in the Kamloops Region for the first time since the outbreak of 1981 to 1983. This followed two consecutive years of population increases. Populations are expected to continue to increase in 1992.

The area and volume of mature and overmature spruce killed by **spruce beetle** increased for the second consecutive year to more than 44 600 ha, mostly north of Mackenzie and north and east of Prince George. This followed seven years of decline. Declining populations in recently windthrown and standing spruce in Bowron Lakes Provincial Park pose no immediate threat to healthy stands. **Northern spruce engraver beetle** killed tops of mature and overmature spruce in parts of the Prince George Region. The area of alpine fir and white

spruce defoliated in northeastern British Columbia by **eastern spruce budworm** declined 40% to 245 000 ha in 135 separate patches north and west of Fort Nelson where defoliation is forecast to continue in 1992. Alpine fir and spruce forests in 61 areas over 31 000 ha, mostly in the Prince George Region and to a lesser extent in the Kamloops and Nelson forest regions, were lightly defoliated by mature **"off-cycle" 2-year-cycle budworms**, up from 29 300 ha in 1990. Immature **"on-cycle" 2-year-cycle budworm** lightly defoliated new shoots of high-elevation fir and spruce in 40 areas over 5050 ha in the eastern part of the Cariboo and Prince George regions, and were present in high numbers in and near Kootenay National Park in the Nelson Region.

More than 1200 pockets containing mature alpine fir recently killed by **western balsam bark beetle** covered 62 500 ha in parts of six forest regions, mostly in the Prince Rupert Region. Mortality of grand fir by **engraver beetles** in the southern part of the Nelson Region declined following three years of outbreak. **Balsam shoot boring sawfly** populations in true firs in parts of the Nelson and Vancouver regions declined to their endemic levels following significant shoot mortality in some stands for up to three consecutive years. Active **balsam woolly adelgid** populations were found on amabilis fir for the first time east of Lillooet Lake, slightly east of the existing quarantine zone in southwestern British Columbia, but damage was not significant.

Western blackheaded budworm populations collapsed in western hemlock near Holberg on northern Vancouver Island, down from a peak in 1989 when stands over 7400 ha were defoliated. There was some recovery of immature trees top-killed during the outbreak. Old-growth western hemlock was defoliated by **western hemlock looper** in 265 patches over more than 50 000 ha in three forest regions, a major increase from eight patches and 1115 ha in 1990. Generally severe defoliation is forcast in 1992, but it may be less severe in some areas due to larval parasitism and disease. Western hemlock was lightly and moderately defoliated by **gray spruce looper** in 34 separate patches over 3850 ha in the western part of the Nelson Region. This was the second year of outbreak, mostly near Slocan and Upper Arrow lakes, and the first in the Nelson Region. An entomopathogen killed up to 38% of the larvae at two sites and could reduce populations further in 1992.

Defoliation of western larch stands by **larch casebearer** in southeastern British Columbia was generally very light after high larval and pupal parasitism in 1991. **Larch sawfly** populations remained endemic in western larch in the East Kootenay, and continued to decline in tamarack in northern British Columbia and the southwestern part of the Yukon Territory where very light defoliation occurred in patches; populations also declined in exotic larch near Terrace, Prince George, Haney, and Vancouver. **Green larch looper** populations in western larch at higher elevations in the West Kootenay collapsed following defoliation in 190 patches over 12 000 ha in 1990, the first defoliation since 1977. New infections and discoloration of western larch by **needle blights** were widespread and conspicuous throughout much of the host range in the Nelson and Kamloops regions, as in 1990.

Black army cutworm populations generally remained at low levels in recently burned and planted sites in interior British Columbia in 1991, as they did in the previous two years. Recently planted seedlings were lightly defoliated by small numbers of larvae at only 4 of 44 sites in wetter parts of the Nelson, Prince George, and Prince Rupert regions. High numbers of cutworm moths were caught in pheromone traps at eight sites and could pose a threat to seedlings in 1992. Fruiting bodies of **Rhizina root disease**, although generally less numerous and widespread than in 1990, killed recently planted seedlings in seven sites in parts of the Nelson and Prince Rupert regions, down from 24 sites in 1990.

Surveys of more than 250 young stands across the province in 1991 found the most common, the most damaging, and the most widespread problems were similar to those in 1990 and included the effects of year-old **climatic injury**, **animal feeding**, and **native needle diseases**. Less common but locally significant were **root diseases**, **terminal and root collar weevils**, and **stem rust cankers**.

The most common pests in coastal seed orchards included **Cooley spruce gall adelgid**, which infested Douglas-fir at five orchards and spruce at two orchards; damage was mostly light but occasionally was severe. **Balsam wooly adelgid** was common on amabilis fir at four seed orchards, **balsam twig aphid** deformed needles and twigs on true firs at two orchards, and **hemlock wooly adelgid** lightly infested trees at one orchard.

In forest nurseries, increased severe infections by **a leaf blight** killed several thousand western red cedar seedlings at two sites in the Vancouver Region. However, seedling **root rots** were less common, and **a shoot blight** found on hemlock seedlings for the first time in British Columbia was treated.

Mortality of up to 47% of the immature and mature conifers by root diseases including ***Armillaria***, blackstain, ***Inonotus***, and ***Phellinus*** **root diseases** in more than a dozen sites surveyed in parts of at least three forest regions, resulted in significant volume losses and created potential hazards in high use recreational areas.

Feeding damage to conifers, including seedlings, by **voles**, **porcupines**, and **squirrels** occasionally resulted in stocking reductions in parts of the Kamloops, Nelson, Prince Rupert and Vancouver regions, and in the Yukon Territory. Recovery of conifers from severe **climatic injury** in early 1989 was generally good.

There was no evidence of damage or change in the condition of trees and ground cover attributable to **acid rain** at 15 sample plots across the province. New mortality from other causes averaged 3% of the trees.

Pests, particularly defoliators, were again numerous and widespread in deciduous forests, particularly in stands of trembling aspen. **Forest tent caterpillar** populations declined overall but still defoliated trees and shrubs at more than 320 locations covering 113 000 ha near Prince George, near McBride, in the Peace River area, and to a lesser extent in the Cariboo and Kamloops regions. **Northern tent caterpillar** defoliated cottonwood and other deciduous hosts over 4260 ha in the Skeena and Wedeene river valleys in the western part of the Prince Rupert Region, in some areas for the third consecutive year. Increased **large aspen tortrix** populations north of Mackenzie and along the Alaska Highway defoliated aspen in about 45 areas totaling 18 000 ha, double the area defoliated for the first time in 1990. Defoliation in southwestern Yukon Territory was widespread and less severe following three consecutive years of infestation. About 72 adult male **gypsy moths** were trapped in 17 areas in British Columbia in 1991 compared with 121 moths in 16 areas in 1990. Some were the Asian biotype, the first record of this race in North America. Discoloration of native birch by **leafminers** remained at low levels in parts of four forest regions. Following earlier declines, **satin moth** populations remained low in the lower mainland, the north Okanagan Valley, and near Golden. Generally declining **western winter moth** populations lightly defoliated maples and other deciduous hosts at one location in the Vancouver Region, but no damage was noted elsewhere. Defoliation of deciduous hosts by **winter moth** was less severe in the lower mainland and on southern Vancouver Island, following a slight increase last year. Garry oak stands in the Greater Victoria area were severely discolored for the sixth consecutive year by high populations of the **jumping gall wasp** and to a lesser degree by an introduced **oak leaf phylloxeran** Defoliation of apple and crabapple trees by an introduced pest, **apple ermine moth**, was common but less widespread and less severe than in 1990 and 1989 when its wide distribution in southern and southwestern British Columbia was first identified. Native and planted dogwoods in the southwestern part of the Vancouver Region were again severely infected by **dogwood leaf blight** which killed lower branches and occasionally killed trees.

Six disease collections were **new occurrence records** within either British Columbia or the Yukon Territory in 1991, and an additional 14 diseases were recorded for the first time on new hosts. Three insects were found beyond their previously known distributions, one was a new species, and one was a first record for the insectary collection at Victoria.

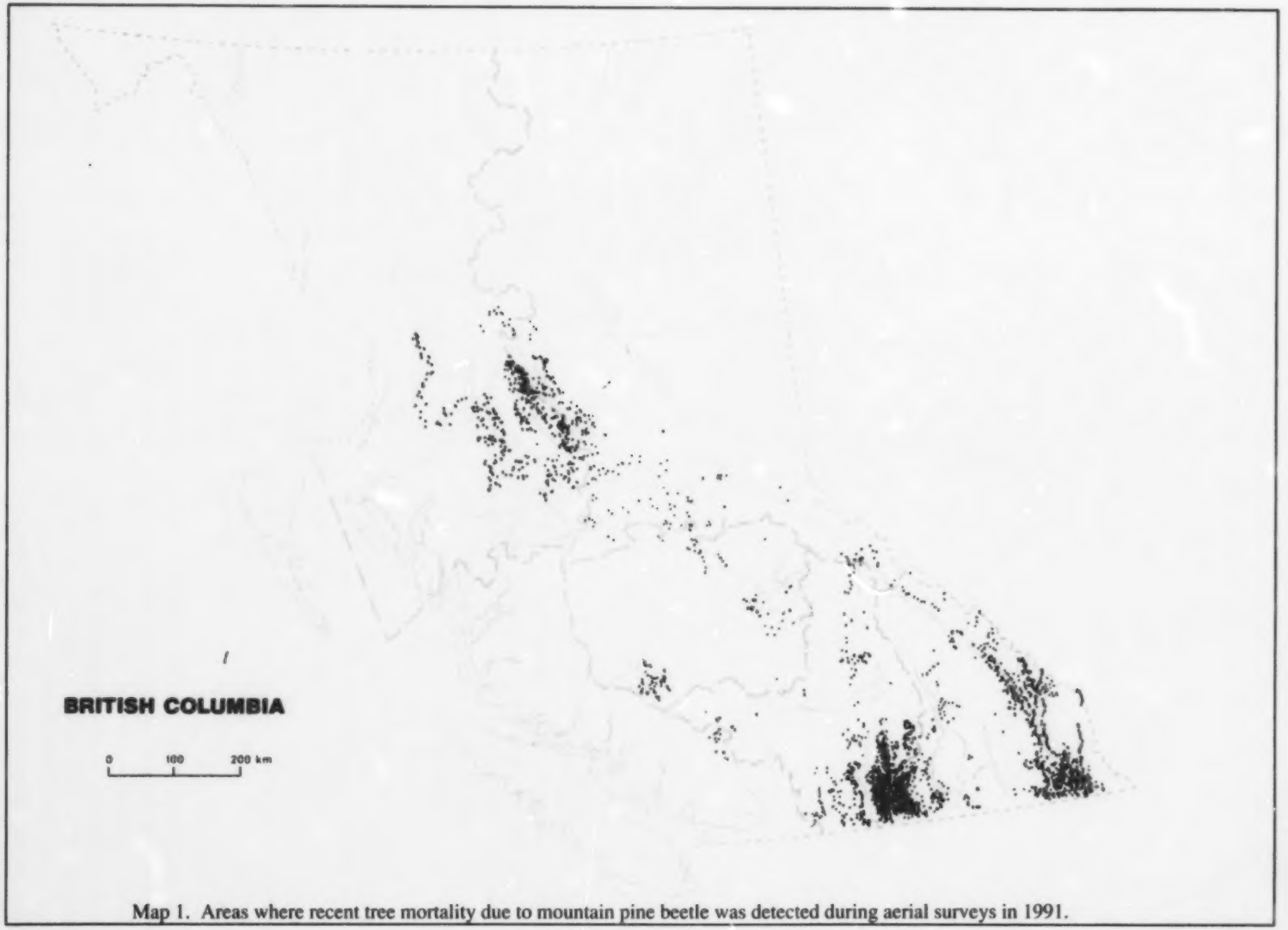
Pine Pests

Mountain pine beetle

Dendroctonus ponderosae

The mountain pine beetle continues to be the most damaging forest insect in British Columbia. The area of lodgepole pine and some western white pine killed by the beetle increased about 16% to more than 49 600 ha in 9065 active infestations (Table 1) from the international border in the southeast to northeast of Terrace (Map 1). This is nearly double the area burned by forest fires in British Columbia in 1991 (27 850 ha), and the volume lost (2 million m^3) represents about 10% of the lodgepole pine annually harvested in British Columbia.

Active infestations continued throughout the six forest regions in British Columbia, and are forecast to continue in 1992. The area of recently killed mature pine increased slightly overall, mostly in the Kamloops Region, to 19 000 ha, up more than threefold from 1990. In the Nelson Region the area containing recently killed mature pine declined to



Map 1. Areas where recent tree mortality due to mountain pine beetle was detected during aerial surveys in 1991.

Table 1. Number, area and incidence of new and old attack of mountain pine beetle by forest region, based on recently killed trees recorded by aerial and ground surveys in British Columbia in 1991.

Forest Region	Number of infestations	Trees killed[a] Area (ha)	Trees killed[a] No. (000)	Stands cruised[b] Vol. (000 m^3)	Stands cruised[b] No.	Avg. yrs. infested	Damage category[c] H	C	R	G	P
							% of trees				
Cariboo	294	350	17	5	2	2	49	11	31	9	0
Kamloops	2685	19 000	3520	1368	5	5	73	10	12	4	1
Nelson	4293	14 675	763	275	22	5	51	18	21	6	4
Prince George[d]	306	9300	334	267	2	5	65	7	11	12	5
Prince Rupert[d]	1417	5850	136	81	1	4	45	0	16	30	9
Vancouver	71	465	7	6	-	-	-	-	-	-	-
Total	9066	49 640	4777	2002	32	5	57	9	18	12	4

a Trees attacked in 1990, discolored in 1991.

b Some stands located in younger infestations may not represent average condition.

c H - Healthy; C - Current, attacked in 1991; R - Red, attacked in 1990; G - Grey, attacked in or before 1989; P - Partial or strip attacked in 1991.

d Estimates include data from the B. C. Forest Service

14 675 ha, down 35%. In other regions, areas of recently killed mature pine were mapped over 350 ha in the Cariboo Region (up 15% from 1990), 9300 ha in the Prince George Region (up 14%), 5300 ha in the Prince Rupert Region (up 30%), and 465 ha in the Vancouver Region (down 14%).

In the Cariboo Region, infestations increased overall to 350 ha from 300 ha in 1990, but declined slightly at Chilko Lake. Recent pine mortality and new attacks increased slightly in mixed conifer stands in the eastern part of the region and are expected to continue to increase in 1992. Pine mortality near Chilko Lake is expected to decline at the west end of Franklyn Arm due to reduced host availability, but susceptible pine to the north and east of the lake are vulnerable to attack.

The area of mature pine killed by the beetle in the Kamloops Region in 1991 increased threefold, following three years of decline, to 19 000 ha. About 3.5 million mature pine (1 368 000 m^3) were killed in about 2685 pockets, mostly over 16 450 ha in the Okanagan Timber Supply Area (TSA). In the Merritt TSA there were 475 pockets of pine mortality totaling 880 ha. Groups of 5 to 10 beetle-killed white pine were again numerous near Adams and Barriere lakes and from Vavenby to Albreda in the Kamloops TSA. Tree mortality is forecast to continue in the Kamloops Region in 1992, mostly in the Okanagan and Merritt TSAs where current attack in five stands averaged 10% (range 3%-24%), down 6% from 1990.

Infestations in the Nelson Region declined to 14 675 ha in about 4290 separate pockets containing an estimated 763 000 attacked trees (275 000 m^3). The declines were mostly in the southern half of the Boundary TSA in the West Kootenay where tree mortality had been increasing for the previous four years. Elsewhere, there was a significant increase in the southern part of the Cranbrook TSA, but little change in the Invermere, Arrow, Kootenay, and Revelstoke TSAs. Infestations along the British Columbia-Alberta border and in Glacier and Yoho national parks were generally stable for the fifth year, but increased threefold in Kootenay National Park. Small groups of recently killed pine were common in the Flathead and Elk river valleys, following an increase in 1989. An average of 18% of the trees were attacked in 1991 in 22 stands surveyed in the region; this is a decline of 8% from 1990 but indicates continuing tree mortality in 1992.

Current attacks were again highest in the East Kootenay (average 24%, range 2-52%); damaged areas included Bull River, Moyie Lake, near Parsons, Golden, and in Kootenay and Glacier national parks. New attacks in the West Kootenay declined overall (average 10%, range 2-19%) in eight stands infested on average for 5 years; the highest levels of attack occurred at West Boundary Creek and in the upper Rock Creek drainage in the Boundary TSA.

The area containing recently killed pine in the Prince George Region increased about 15% to 9300 ha, following an increase to 8000 ha from 1989 to 1990. Most of the 305 separate infestations, which contained about 334 000 trees (267 000 m^3), again were in drainages northwest of Fort St. James, and included areas near Takla and Trembleur lakes where most of the increases occurred, and some areas in the Skeena, Sustut, Middle, and Tachie river valleys. Pine mortality is forecast to continue in the region in 1992, but tree mortality will decline in the Fort St. James area. New attacks in two stands in the area averaged 7%.

Aerial and ground surveys by the British Columbia Forest Service in Mt. Robson Provincial Park and west of Jasper National Park located no new beetle-killed pine, but 104 baited pine were newly attacked. Annual cut-and-burn control operations, which have been conducted since 1985, are scheduled to treat these trees in 1991-92.

Infestations in the Prince Rupert Region increased about 40% in area to 5850 ha and contained about 136 300 trees (81 160 m^3) in 1417 separate infestations. The increase, following a decline in 1990 in the western part and to a lesser extent in the eastern part of the region, was in the lower Nass River Valley in the Kalum TSA and parts of the Bulkley and Morice TSAs. Tree mortality is forecast to decline in 1992; this prediction is based on the low proportion (less than 1%) of the trees attacked in 1991 in a stand infested for about 4 years.

The number and area of mature lodgepole pine killed by mountain pine beetle in the Vancouver Region declined to the lowest level recorded in the region since 1981 when infestations were first mapped in the Homathko River Valley and east of Pemberton. About 7000 trees (5000 m^3) were recently killed in about 70 separate pockets totaling 465 ha, down from 540 ha, in widely scattered parts of the Soo TSA mostly east of Pemberton. Based on the trend of declining host availability over the past 6 years, pine mortality is expected to decline further. Surveys of the declining and remote infestations were discontinued in 1990.

Overwintering mortality of the mountain pine beetle was common, particularly in thinner barked trees in the southern interior in early March. A ratio of progeny to parents in May-June greater than 4.1 indicates increasing populations; such ratios occurred at only 16 of 54 locations, and they were reflected in reduced current/green attacks. Ratios of less than 2.5 indicate declining populations and these occurred at 29 locations. The average regional values ranged from 2.2 to 3.9, down from 4.3 to 13.1 in 1990; this indicated declining populations for flight and attack during 1991.

Overall, infestations are forecast to continue in 1992 throughout many recently infested pine stands in parts of five forest regions. This prediction is based on the number of new attacks in 31 representative stands infested on average for 5 years. Current attacks declined from 1990 levels in four regions. The frequency of new attacks in all regions averaged 9%, down 9% from 1990, and ranged from 18% in the Nelson Region to 0% in the western part of the Prince Rupert Region.

Increased numbers of western white pine were also killed by mountain pine beetle in the northern part of the Kamloops Region for the second consecutive year. Other bark beetles such as western pine beetle, *Dendroctonus brevicomis*, and red turpentine beetle, *D. valens*, were less common than in 1990 in parts of the Kamloops and Nelson regions, respectively. Pine engraver beetle, *Ips pini*, which had been common in mountain pine beetle infestations in the interior regions during 1966-1988 also remained at low levels. Attacks by ambrosia beetles, *Trypodendron* spp., were less widespread in stands infested by mountain pine beetle in parts of the Cariboo, Nelson, and Prince George regions.

Single-tree disposal and salvage of beetle-killed and adjacent susceptible pine continued at high levels in most beetle-infested TSAs. Salvage harvesting of economically accessible beetle-killed pine may be affected by high inventories in a declining market. There were no reports yet of reduced annual allowable cuts as a result of earlier increased salvage harvesting, but this is likely to happen soon.

Pinewood nematode

Bursaphelenchus xylophilus

The nematode remains extremely rare in forests in British Columbia and the Yukon Territory. About 2000 samples have been examined from recently dead or dying trees, logs, low grade boards, and potential vectors collected throughout British Columbia. Only a few individual predisposed trees

have been affected at widely scattered locations. Only six of those samples (0.3% incidence) examined in the region since 1980 contained pinewood nematode. There was none in 319 extractions from western hemlock and western red cedar. A single *Monochamus* woodborer has been detected in only one of about 575 hemlock logs but none has been found in cedar examined in 16 coastal log storage yards in 1990.

Prior to the ban on exports of non-kiln-dried softwood from Canada imposed by the European Economic Community, which recently has been granted a further 1 year deferral, a cooperative study was initiated to investigate control of the nematode and its potential vector, *Monochamus* spp. by heat treatment. In cooperation with the Council of Forest Industries (COFI) and Forintek, a total of 31 dry land sorts and areas of felled and bucked material were examined throughout the region by FIDS in 1991. Only nine sites contained small numbers of affected logs. Twenty-four logs were selected from a site near Squamish. Insects present in a representative sample included the whitespotted sawyer beetle, *Monochamus scutellatus*, a cerambycid woodborer, *Leptura* sp., darkling beetles, *Ipthimus serratus* and *Phellopsis porcata*, and a carabid predator, *Scaphinotus nagusticollis*. Results of the heat pasteurization trial are pending.

Pine needle sheathminer

Zelleria haimbachi

Defoliation and needle mining of lodgepole pine by sheathminer in the Kamloops Region declined overall by more than half to 11 700 ha in 52 separate areas. However, pine were defoliated by the sheathminer in association with western spruce budworm, *Choristoneura occidentalis*, in an additional 12 infestations totaling 13 500 ha. Populations in the Vancouver Region collapsed following five years of discoloration, and populations remained low near Grand Forks in the Nelson Region after their collapse in 1990.

Discoloration of immature lodgepole pine regeneration in the Kamloops Region was light over 5875 ha and moderate over 5075 ha; the level of damage was similar to that recorded in 1990. Severe discoloration was in association with western spruce budworm and was limited to three areas totaling 650 ha south of Salmon Arm near Shuswap Lake and to immature pine in a 30-ha plantation at Bear Creek northeast of Kelowna. This was only the second record of damage in the Okanagan since an infestation in the early 1950s. Most discoloration was in 29 areas from Seymour Arm to the north end of Adams Lake, and near Clearwater and Avola in the North Thompson River drainage. The declining populations were mostly near Barriere lakes and adjacent parts of Adams Lake.

Populations of the sheathminer in pine stands in the Vancouver Region near Pemberton, D'Arcy, Harrison Lake, near Boston Bar, and on Texada Island collapsed after being active in some areas for five consecutive years. Although increment reduction may have occurred following larval mining and defoliation for up to five consecutive years, there was no apparent reduction of lateral or height growth, and infested stands are expected to recover. Overwintering population assessments were insufficient to forecast trends in 1992.

A pine sawfly

Neodiprion nanulus contortae

Sawfly populations in the Vancouver Region collapsed following two consecutive years of severe defoliation of lodgepole pine in widespread locations at higher elevations in the lower mainland. Populations in the eastern part of the Prince Rupert Region also declined.

There was no evidence of larval feeding in a plantation at Spuzzum Creek, near Yale, where 15- to 20-year-old lodgepole pine over 15 ha had been severely defoliated in previous years. Previously defoliated pine in urban areas near Mission showed signs of recovery after having lost up to 90% of the older needles.

Pine needle diseases

Elytroderma deformans
Lophodermella concolor
Lophodermella montivaga
Scirrhia pini

Infection of year-old needles of lodgepole and ponderosa pines by native needle diseases was again common in the Cariboo, Kamloops, and Nelson regions, and was present to a lesser extent in the Vancouver Region.

Infection of year-old and older lodgepole pine needles by Lophodermella needle diseases was severe and widespread in the Kamloops and Nelson regions. In the North Thompson River drainage in the Kamloops Region, infection was severe for the second consecutive year. Up to 50% of the year-old needles on up to 80% of the regeneration and mature lodgepole pine were discolored in patches in the

Lillooet TSA, including areas in the Marshall and Hurley creek valleys, at Miledge Creek north of Blue River, and again throughout the Okanagan Valley drainages.

In the Nelson Forest Region, patches of lodgepole pine totaling up to 5800 ha were severely discolored in the Bull River Valley and in the Flathead River and Lodgepole Creek drainages. Discoloration was widespread in 25- to 35-year-old stands over 300 ha in the Spillimacheen and White river valleys; damage was generally light although moderate levels of discoloration occurred in some areas. Infection of western white pine was light and occasionally moderate in the western part of the region.

Up to 60% of the year-old needles, mostly in the lower crowns of immature lodgepole pine, were infected by red band needle disease, S. pini, in patches up to 5 ha west of Lac La Hache in the Cariboo Region. Infection of the mid-crowns of most regeneration white pine was common from Albreda to Avola in the Kamloops Region. Successive years of severe infection in immature lodgepole pine stands result in premature needle loss and increment reduction.

Infection of ponderosa pine by Elytroderma needle disease is widespread throughout much of the host range in the Cariboo and Kamloops regions and is present to a lesser extent in the Nelson Region. Severe annual infections have resulted in premature needle loss on most trees over widespread areas. Nearly half the crowns on mature and immature trees were infected and discolored from 100 Mile House to Chasm in the Cariboo Region, and up to 80% of the year-old needles were discolored and 80% of the trees were broomed in stands near Kamloops Lake.

European pine shoot moth
Rhyacionia buoliana

The shoot moth is established in exotic pines in localized urban areas including the Okanagan Valley, the lower mainland, and from Victoria to Courtenay. There has been no evidence of shoot moth populations in native pines.

An average of 30% (range 20-40%) of the new shoots of exotic pines at two urban sites in Penticton, where infested and distorted shoots have occurred annually for many years despite periodic treatments, were again infested.

Surveys in 1989 detected the shoot moth on Douglas-fir, which is the first record on this host in North America. Only two Douglas-fir shoots in a mixed conifer Christmas tree plantation at Richmond in the Vancouver Region were infested and three more were found in 1990. These infestations were probably due to the immediate proximity of numerous severely infested Scots pine. No Douglas-fir were infested in 1991 following treatment of the infested trees.

Scleroderris canker
Gremmeniella abietina

A North American strain of this fungus, but not the introduced pathogen, has been found only rarely as a lower branch saprophyte near Penticton, Canal Flats, Castlegar, and Kimberley between 1968 and 1978 during surveys of native lodgepole, ponderosa, and whitebark pine in British Columbia.

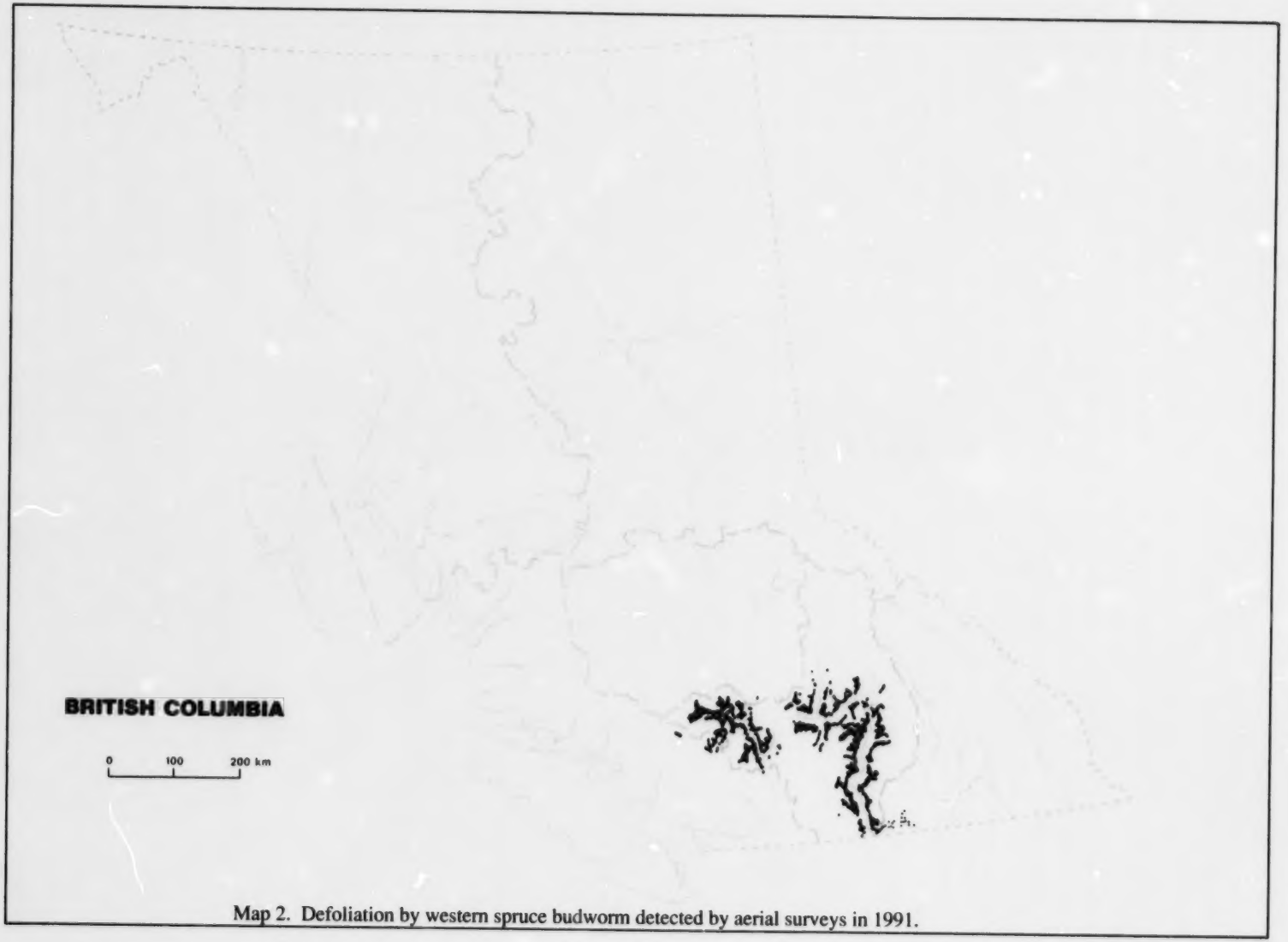
Formal surveys for the introduced Scleroderris canker were all negative and were discontinued in 1988.

Douglas-fir Pests

Western spruce budworm
Choristoneura occidentalis

Mixed-age interior Douglas-fir in parts of three forest regions were defoliated by western spruce budworm over 382 000 ha in 1991 (Map 2); this is nearly double the area affected in 1990 but less than the peak of 800 000 ha in 1987. In addition, lodgepole pine over 13 500 ha in the Kamloops Region were defoliated by the western spruce budworm, in association with a pine needle sheathminer, *Zellaria haimbachii*. There were nearly 800 separate areas of infestation in Douglas-fir forests of which 97% (372 000 ha) were in the Kamloops Region, 1% in the Nelson Region, and 2% in the Vancouver Region. Trace defoliation was detected over about 10 ha west of Clinton in the Cariboo Region, the first in the area since 1986.

Defoliation also intensified in 1991; light defoliation occurred on 28% of the area, moderate on 59%, and severe on 13%, compared with 46%, 52%, and 2%, respectively, in 1990. The most severe



Map 2. Defoliation by western spruce budworm detected by aerial surveys in 1991.

defoliation occurred on 49 500 ha in 100 patches west of Lillooet, near Lytton, Ashcroft, Merritt, Kamloops, Shuswap Lake, Vernon, Kelowna, and Penticton.

Areas of expanded defoliation totaled about 200 000 ha. These included the Okanagan TSA including the Shuswap, (where defoliation increased 36% to 240 500 ha) the Kamloops TSA (up eightfold to nearly 70 000 ha), the Lillooet TSA (up threefold to 78 250), and the Merritt TSA (up more than sevenfold to 1800 ha). Areas of infestations increased about fourfold in the Boundary TSA in the Nelson Region, and by 50% near Pemberton in the Vancouver Region.

Of the total area infested since 1985, 49% has been defoliated for 1 year, 36% for 2 years, 9% for 3 years, and 1-3% for each of 4, 5, and 6 years.

Parasitism of late-instar larvae occurred at 16 of 18 sites sampled in two regions, and averaged 6% (range 0-21%); as in 1991, parasitism was mostly by tachinids, ichneumonids and braconids. An entomopathogen, *Beauvaria* sp., was isolated from larvae in 14 collections in which an average of 38% (range 1-85%) were killed. The presence of *Beauvaria* in populations in the Nelson Region reduced the extent and severity of defoliation from that forecast; an average of 45% of the buds were infested in spring 1991, up from 25% in 1990.

Still, 20% more egg masses than in 1990 were collected at 63 infested stands in three regions, indicating an overall increase(Map 3). Defoliation is forecast to be severe at 42 of the sites, mostly in the Kamloops and Nelson regions. Moderate defoliation is forecast at 16 sites and light defoliation at 5 sites. Additionally, egg sampling by the British Columbia Forest Service at 201 sites in three districts in the Kamloops Region indicated severe defoliation at 10% of the sites mostly in the Vernon District, moderate defoliation at 27% of the sites, light defoliation at 54%, and none at 9% of the sites, mostly in the Salmon Arm District.

Tree mortality, top-kill, bud mortality, increment loss, and tree deformity due to successive years of severe defoliation are common but vary by site. Monitoring of the impacts of defoliation on young open-growing Douglas-fir continued at 64 research plots in the Kamloops Region. Tree mortality in 1991 averaged 10% (range 3-12%). A trend of increasing tree mortality with increasing years of defoliation has been determined (R. Alfaro, Forestry Canada, Victoria, personal communication).

Aerial applications of *Bacillus thuringiensis* var. *kurstaki* by the British Columbia Forest Service were conducted over about 3000 ha near Westwold and Pillar Lake in the Kamloops Region in 1991.

As part of a study to improve and calibrate detection methods for western spruce budworm, mid- to late-instar budworm larvae and adult males were monitored in four regions at 11 sites with a history of budworm outbreaks but still with low populations. Up to 99 larvae per tree were collected per 1 m^2 beating (three branches on each of 25 trees/plot) and up to 605 male adults were caught in a total of 54 traps. Further analysis and sampling are planned to correlate numbers of larvae with population potential and damage.

Douglas-fir tussock moth

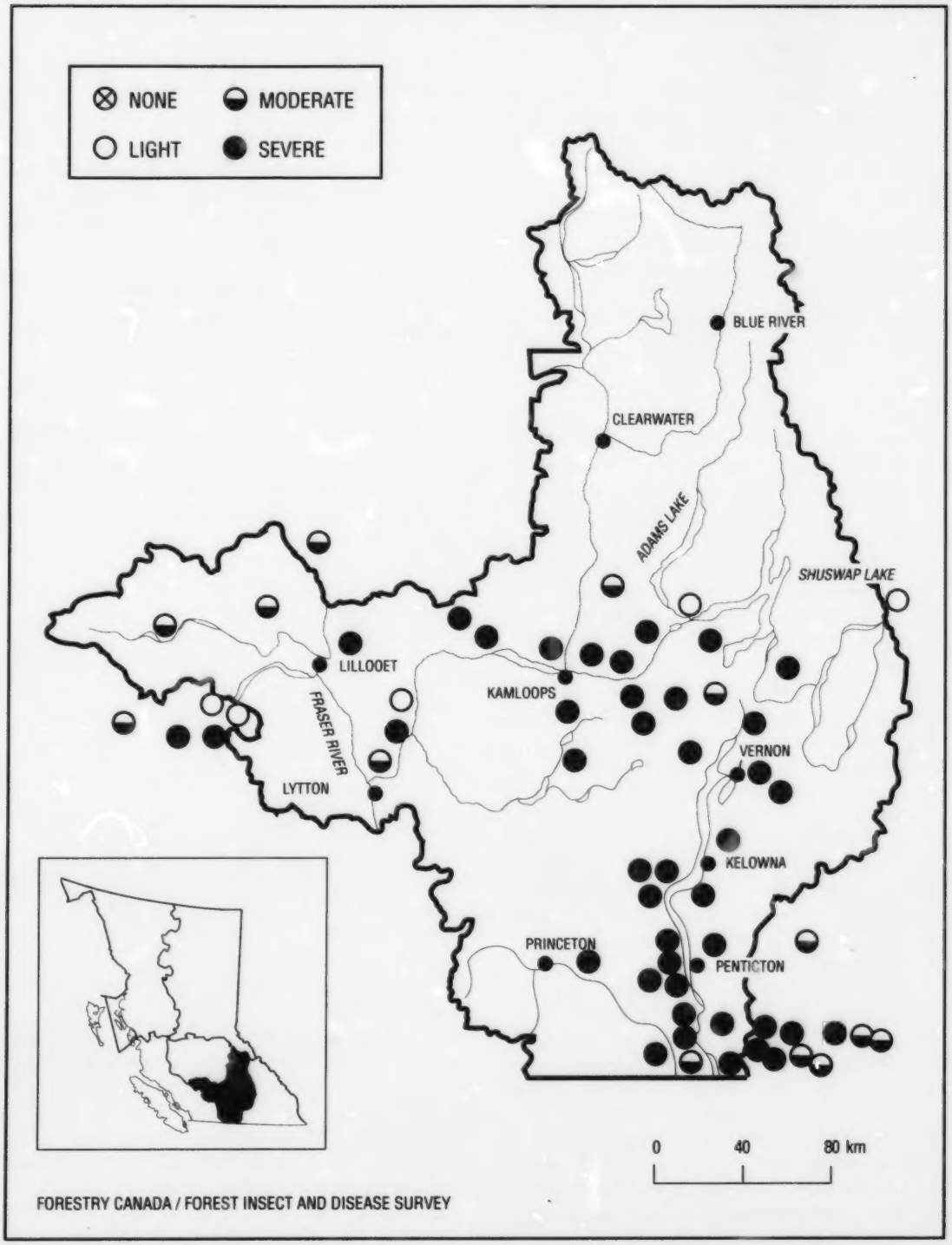
Orgyia pseudotsugata

Douglas-fir trees were severely defoliated in eight areas totaling 135 ha west of Kamloops, and small groups of hedgerow and ornamental Douglas-fir near Abbotsford, Chilliwack, and Clearbrook in the Vancouver Region were defoliated for a second consecutive year. This followed population increases detected in standard three-tree beating samples in natural stands in the Okanagan and Thompson valleys in 1989 and 1990, and for the first time since 1983 in the Fraser Valley. Ornamental Douglas-fir and spruce in urban areas in Kamloops, Vernon, Kelowna, and Penticton were defoliated, some for the fourth consecutive year. However, populations which had increased in 1990 and early 1991 near Hedley and Keremeos declined due to viral infection.

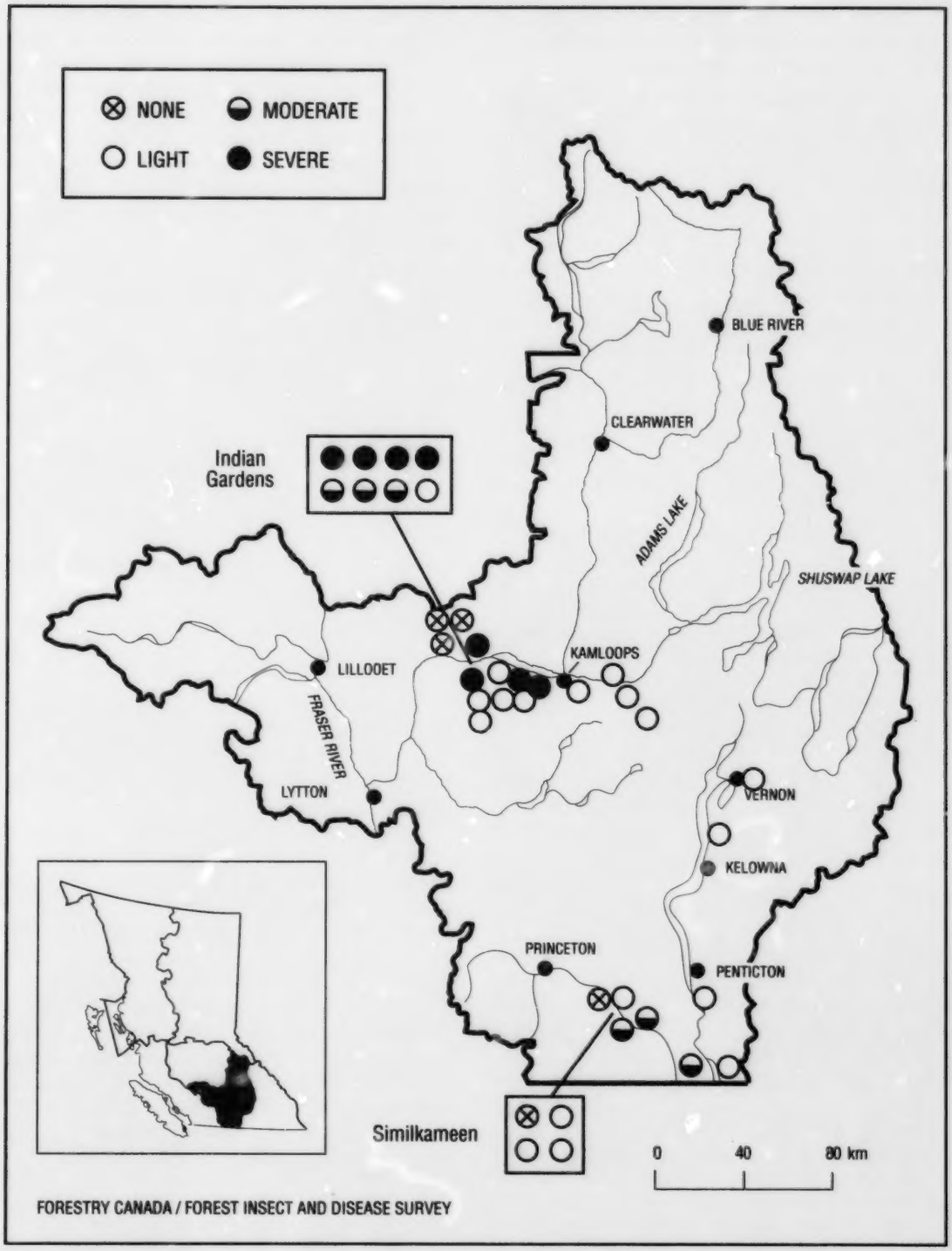
The number of male adults in pheromone-baited sticky traps placed in selected Douglas-fir stands with the greatest historical frequency of outbreaks increased for the sixth consecutive year. About 3807 adult males were trapped in 92% of the traps at 17 permanent monitoring sites in the Kamloops Region. This is 70% more than the number trapped in 1990 and more than double the number trapped in 1989. The number of male adults trapped in the western part of the Nelson Region also increased to 443 caught in 12 traps at two locations, compared to 156 adults in 1990.

Additional traps were placed singly about 1 km apart in five areas in the Kamloops Region to more precisely locate any infestation. These attracted 3262 male adults in 54 of 55 traps, up from 2233 in 1990 and 1782 in 1989. A further 6176 male adults were trapped at 186 locations monitored by the British Columbia Forest Service, up from 1616 at 80 locations in 1990.

Trap data and the presence of egg masses or defoliation in 1991 at 32 of 37 sites (Map 4) indicate the potential for severe defoliation of Douglas-fir at eight sites, moderate defoliation at six sites, and light



Map 3. Defoliation by western spruce budworm forecast for 1992, based on 1991 egg surveys.



Map 4. Defoliation by Douglas-fir tussock moth forecast for 1992, based on 1991 egg surveys.

or trace defoliation at 18 sites. Defoliation may occur in patches from Keremeos to north and west of Kamloops, near Chilliwack, and to a lesser degree in the western part of the Nelson Region.

Treatments of populations over 200 ha near Savona with two virus types (Virtuss and TM-Biocontrol-1) and an experimental pheromone male confusion trial near Hedley were completed following delays in population development. Post spray results from Savona indicated a significant population reduction. Preliminary results from Hedley indicated mating was effectively blocked.

Douglas-fir beetle

Dendroctonus pseudotsugae

Nearly 3000 groups of recently killed Douglas-fir totaled about 3800 ha, up from 2700 ha in 1990. Most of the recently killed trees were in groups of 2 to 15, but some patches contained up to 250 dead trees. Most of the tree mortality occurred in the Fraser River drainage in the Cariboo, Kamloops, Prince George and Vancouver regions, although lesser damage occurred in the Nelson Region and in the eastern part of the Prince Rupert Region. This was the fourth consecutive year in which the number of Douglas-fir killed by the beetle increased. Many of the trees were predisposed by root disease.

Most of the estimated 33 000 (71 200 m^3) recently killed trees in the Cariboo Region were again widely scattered in 2030 separate pockets totaling about 1785 ha, down slightly from 1990. Most were in or near previously infested patches from Clinton north to Quesnel and from Horsefly west to Redstone. The area containing recently killed trees in the military training area near Riske Creek increased slightly to 216 patches totaling 390 ha, up from 176 patches totaling 370 ha in 1990. In the Kamloops Region more than 700 groups were widely scattered in the Thompson River drainage over a total of 235 ha, a threefold increase. Most groups of beetle-killed trees occurred from Cache Creek to Pavilion, in the Deadman River Valley, and there were a few patches between Barriere and Clearwater. Mature beetle-killed Douglas-fir were less numerous throughout the Rocky Mountain Trench in the Nelson Region in scattered groups from south of Radium to the international border. Smaller groups were less common in the West Kootenay. Douglas-fir mortality in 200 patches west of Prince George and south of Valemount increased to 1545 ha, up from 800 ha in 1990. A patch of about 300 trees at the east end of Francois Lake in the Prince Rupert Region killed in 1990 (the first mortality from the beetle in the area in recent years) was harvested and no additional tree mortality was recorded. In the Vancouver Region, beetle-killed trees were mapped in 57 areas over 235 ha, which is similar to the damage recorded in 1990. This included 13 patches in the Anderson River drainage and more than 40 patches totaling 140 ha near Lillooet Lake.

The number of new attacks in trees adjacent to recently killed trees indicates that mortality of mature and overmature Douglas-fir will likely continue in 1992, particularly in the Cariboo Region. In the military training area near Riske Creek, 17% of the trees are currently attacked, up 6% from 1990. Elsewhere in the region 3% were attacked down 11% from 1990. Tree mortality is forecast to continue in stands predisposed by fire and root disease north of Golden but a decline is forecast from Invermere south to Cranbrook.

Western false hemlock looper

Nepytia freemani

Defoliation of Douglas-fir by western false hemlock looper occurred in the Kamloops Region for the first time since 1977 over about 10 ha at Jamieson Creek north of Kamloops. This followed three consecutive years of population increases.

About 110 larvae, up from 33 in 1990 and 20 in 1989, were collected in standard FIDS samples at permanent sample sites from Savona to Chase, Kamloops to Barriere, Penticton, the Similkameen River Valley, and near Spences Bridge. However, the low numbers of larvae and the few eggs on needles of Douglas-fir indicate that populations are still too low to cause visible defoliation in 1992. Periodic infestations have occurred in parts of the Kamloops Region. The most recent infestation was in 1983-84. These infestations are usually concurrent with infestations of Douglas-fir tussock moth, *O. pseudotsugae*, which increased and defoliated natural stands elsewhere in the region this year.

Spruce Pests

Spruce beetle

Dendroctonus rufipennis

The area and volume of mature white and Engelmann spruce killed by this beetle in British Columbia increased for the second consecutive year; this followed seven years of decline. Most of the infested spruce mapped in aerial surveys was in the Prince George Region and totalled over 44 600 ha, up from 13 150 ha in 1990. The major increase was in standing mature spruce north of Mackenzie and to a lesser extent north and east of Prince George near Carp and Weedon lakes, and in the Parsnip and McGregor river drainages (Map 5).

Tree mortality in the Prince George Region increased for the second consecutive year. Beetle-killed mature spruce were mapped in more than 1210 widely scattered patches totaling 44 400 ha. According to data largely provided by the British Columbia Forest Service, the increase in mortality was in standing spruce in mixed species and age classes over 32 400 ha west of Williston Lake in the Mackenzie TSA. Increased mortality over 10 630 ha also occurred in the Prince George TSA in the Summit, Davie, Carp, and McLeod lakes area, at Seebach and Averil creeks, and the upper Parsnip and McGregor river drainages. Mortality of standing trees occurred in four patches totaling 200 ha north of Fort St. James, and east of Fort Nelson, but elsewhere in the region populations generally declined to endemic levels. Only a few new attacks occurred in windthrow, trap trees and some standing trees between Pine Pass and Chetwynd, south of Dawson Creek, and southwest of Hudson's Hope.

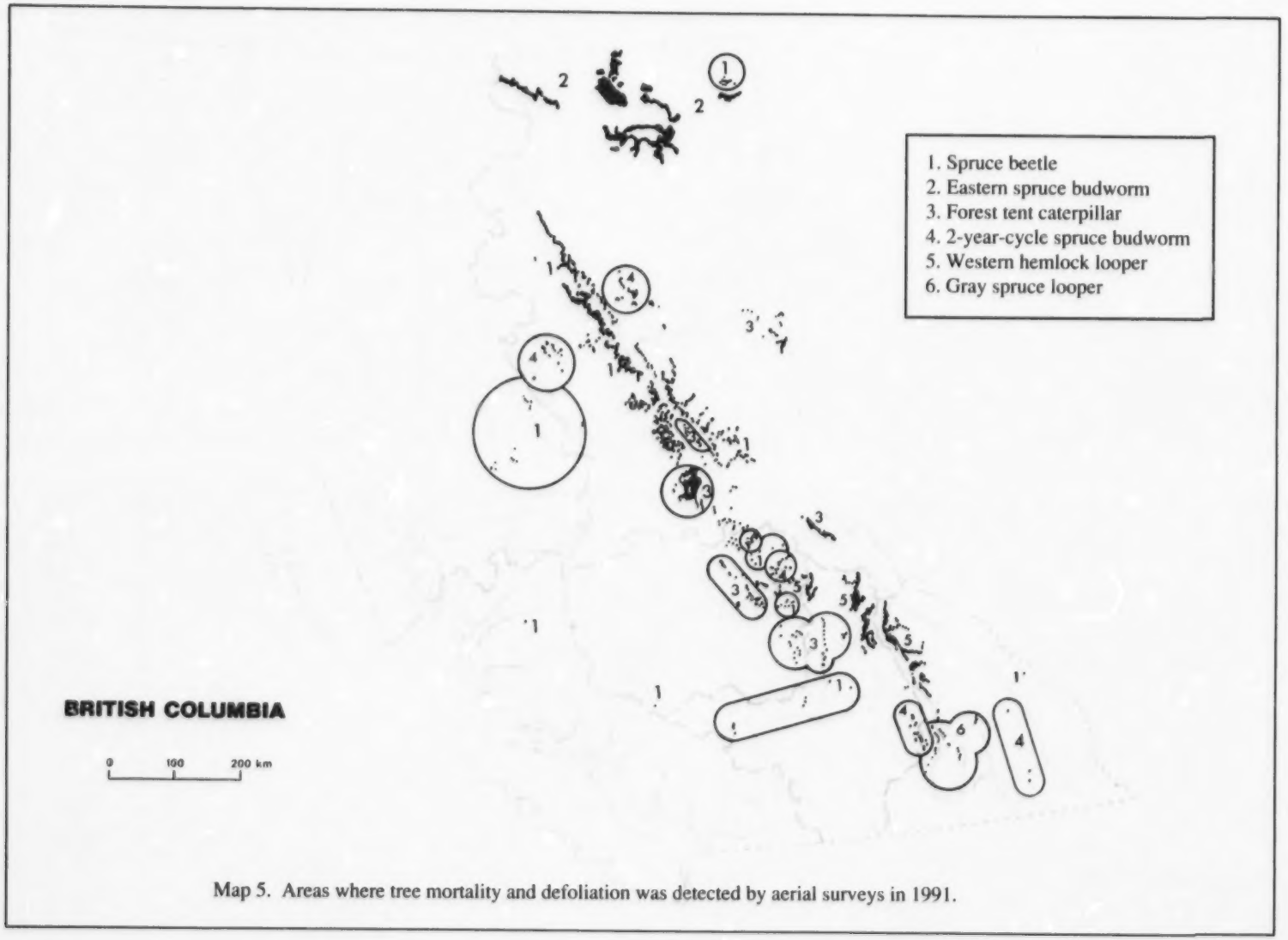
Spruce beetle populations found in 20 of 28 areas examined in cooperative inter-agency surveys of beetle-infested spruce stands north of Mackenzie in the Prince George Region may be a potential threat to adjacent healthy spruce when populations mature in 1993. Evidence of attack since 1985 was present in or adjacent to most stands and, except for a small flight in 1990, most populations were in the 2-year cycle which peaked in 1989. New (1991) attacks were common in trees previously attacked in 1989 or 1990; these were mostly light, although some attacks were severe. Most of the recent tree mortality occurred in the Chunamen Creek drainage west of Williston Lake, where new attacks were found in an average of 35% (range 0-75%) of the green standing spruce in mixed species and age classes at 16 sites. New attacks at 10 sites in the Phillips, Mischinsinlika, and Trappers creek drainages averaged 16% (range 1-53%), but no new attacks were found at an additional two sites.

Proposed stand treatments prior to brood emergence in 1993 include harvesting and lethal and non-lethal trap trees; these treatments and additional probes and long-term monitoring could limit the threat to adjacent non-infested stands.

There was no increase in the infestation in Bowron Lake Provincial Park which was largely confined to mature and overmature spruce windthrown in 1990 in 65 patches totaling 700 ha. Follow-up surveys in cooperation with the British Columbia Forest Service and British Columbia Ministry of Parks in 15 representative patches of blowdown on the west arm of Isaac Lake and facing Wolverine Bay found less than five new attacks per site in single widely scattered 1991 windthrown spruce, too few to be a potential hazard in 1992-93. Patches of windthrown spruce attacked in 1990 contained an average of 12 attacks per square metre of bark area. Most (80%) broods were 2-year-cycle, which are forecast to emerge and attack susceptible host material next year. Elsewhere in the region, recent tree mortality totaled about 65 ha in 64 widespread pockets near Barkerville, in the Mitchell, Matthew, and Cariboo river drainages, and near Towkuh, Big Valley, Rebman, and Alice creeks; a similar level of mortality occurred in 1990.

Recent mortality of mature spruce in the Kamloops Region was generally confined to previously infested stands in seven separate patches totaling 335 ha, down from 17 patches over 1000 ha in 1990. Declines, mostly due to harvesting and host depletion, occurred in the Tulameen River drainage west of Princeton, between Anderson and Bridge lakes west of Lillooet, and near the south end of Adams Lake.

In the Nelson Region, populations generally were at endemic levels for the third year. Recent tree mortality occurred only over 20 ha at Ensign Creek in the Blaeberry River drainage north of Golden where a third of the mature spruce adjacent to recently logged areas were attacked. Small numbers of mature spruce in the upper Flathead River drainage have died from the combined effects



Map 5. Areas where tree mortality and defoliation was detected by aerial surveys in 1991.

of climatic injury in early 1989 and beetle attacks in 1990.

Populations of northern spruce engraver beetle, *Ips perturbatus*, increased slightly in parts of the Prince George Region in 1991. The top third of the crowns of mature and overmature spruce were killed at widely scattered locations in the Torpy River drainage and west of Takla Lake north of Fort St. James. This followed slight population increases in spruce windthrow and trap trees in 1990.

Spruce aphid

Elatobium abietinum

Populations of spruce aphid in coastal areas of the Vancouver Region, particularly at Campbell River, defoliated immature and mature Sitka and ornamental spruce for the second year, and populations increased significantly on the Queen Charlotte Islands.

Defoliation was generally less severe than in 1990; however, some mature Sitka spruce in the Campbell River area that were severely defoliated in 1990 and 1991 are not expected to recover. Elsewhere, populations declined from Powell River to Langdale, on Texada Island, and east to Hope.

Increased spruce aphid populations on the Queen Charlotte Islands severely defoliated coastal spruce regeneration in the Lawn Hill area and a 100-ha plantation near Heather Lake. Light and moderately defoliated spruce were common elsewhere, including from Queen Charlotte City to Tlell, at Port Clements, Tow Hill, Peel Inlet, Moresby Camp, and half the saplings were defoliated over 2 ha at a campsite at Peel Inlet.

True Fir Pests

Budworms

Choristoneura spp.

Defoliation of spruce and alpine fir forests by eastern and 2-year-cycle budworms covered 245 400 ha and 34 350 ha, respectively, in parts of four forest regions in 1991 (Map 5).

Defoliation of current foliage and some older foliage of white spruce and alpine fir by eastern spruce budworm, *Choristoneura fumiferana*, was mapped in more than 135 separate patches north and west of Fort Nelson totaling more than 245 000 ha. This is down 40% from the area affected in 1990, as predicted, but it is still double the area defoliated in 1989. Defoliation extended into the Northwest and Yukon territories. Defoliation, which occurred in some areas for the seventh consecutive year, was light over 90% of the affected area, and moderate over the remainder. Most moderate defoliation was near Liard Hot Springs, and light defoliation was widespread in the Fort Nelson River Valley between Klua and Cridland creeks.

Populations are expected to persist in 1992 in many previously defoliated stands in the Liard and Fort Nelson river drainages. This prediction is based on egg masses on spruce foliage at two sites in the Snake River drainage, at one site in the Liard River drainage, and at Clarke Lake.

Two aerial applications of a commercial formulation of *Bacillus thuringiensis* var. *kurstaki* were completed by the British Columbia Forest Service to protect mature spruce seed production stands and adjacent young stands near Fort Nelson. Five blocks totaling 525 ha at three locations were treated with (Dipel (R) 132).

Defoliation of spruce and alpine fir forests by 2-year cycle spruce budworm, *Choristoneura biennis*, was generally light over 34 350 ha in 104 separate infestations in three forest regions. This was up slightly from 30 000 ha in 170 infestations in 1990.

Mature 'off-cycle' budworm defoliated alpine fir and spruce over 6775 ha near Keefer Lake east of Cherryville in the Kamloops Region. In the eastern part of the Nelson Region defoliation occurred in the St. Mary River Valley and at Bugaboo Creek over 1525 ha, but not at Dewar and Vowell creeks. This was up from 5850 ha defoliated in 1989, the most recent year with mature larvae in these areas. For the first time since the 1960s, mostly light defoliation was mapped over 15 000 ha in the Omineca River drainage between Duckling and Ominicetla creeks and at Ankwill Creek north of Fort St. James. Defoliation was also light over 8000 ha in the Ospika and Davis river drainages north of Mackenzie, where defoliation was mapped for the first time in 1989 over 11 385 ha. Increased populations north of Chapman Lake in the eastern part of the Prince Rupert Region lightly defoliated stands over about 500 ha.

Immature 'on-cycle' budworm larvae lightly defoliated current foliage of high-elevation fir and spruce over 250 ha in a patch near McBride in the Prince George Region, and on 3250 ha in more than 40 stands in the eastern part of the Cariboo Region. Light defoliation in the Vermilion and White River drainages in the East Kootenay, first recorded in 1990, covered 1300 ha.

During 1991, 34% of the buds were infested in the Vermilion River drainage, indicating increasing populations and potential light and occasional moderate defoliation in 1992 when larvae mature. Only 8% of the buds were infested in the White River Valley, indicating declining populations. Further bud counts to determine population trends will be completed in early 1992.

Populations continued to be monitored in representative sites in four regions to improve identification and monitoring methods. About 1600 adult males (average 827 per trap) were collected in 50 non-sticky traps at 10 sites in four regions, and up to 88 larvae (average 11) were collected per location. Further study is necessary before numbers can be correlated with population damage and potential.

Western balsam bark beetle

Dryocoetes confusus

The areas of recently killed mature alpine fir mapped during aerial surveys totaled 62 500 ha in more than 1200 separate pockets in parts of all six forest regions, mostly in the Prince Rupert Forest Region.

Infestations, which have persisted in the Prince Rupert Region for many years, were mapped in more than 240 areas totaling 48 000 ha. Most of the tree mortality was in chronically infested mature stands in the southern part of the region in the Ootsa, Whitesail, and Morice lakes areas, and to a lesser extent in the McKendrick Pass area north of Smithers, near Cranberry Junction, and in the upper Skeena River drainage. Surveys in the southern part of the Morice TSA in 1990 found that up to 30% of the mature alpine fir volume had been killed in parts of the Mosquito and Shelford Hills areas, in upper Walcott Creek, and near Dome Mountain. An estimated 3% of the mature alpine fir have been killed by the beetle over 17 300 ha in the Cassiar TSA since 1987.

Most mortality in the Prince George Region was in chronically infested areas northeast and northwest of Prince George and in newly infested areas northwest of Fort St. James totaling 6900 ha in more than 145 widespread patches. This was up from more than 75 separate areas totaling 4000 ha in 1989 when coverage was similar.

In other regions, areas containing recently killed alpine fir increased overall, to 865 ha in the Cariboo Region, to 1700 ha in the Kamloops Region, and to 3850 ha in the Nelson Region, but declined slightly in the Vancouver Region to 1100 ha in about 70 patches.

Annual fluctuations in the areas containing recently killed mature alpine fir are due in part to the limited aerial surveys in the more remote areas, and in part to accuracy of detection of recently dead trees, some of which retain reddened needles for at least 5 years.

Fir engraver beetle

Scolytus ventralis

The number of semimature and mature grand fir killed by fir engraver beetles in the southern part of the Nelson Region declined following three years of outbreak. Only three patches of recent tree mortality totaling about 10 ha were mapped in the Pend-d'Oreille area of the West Kootenay. This is a decline from 1990 when widely scattered trees were attacked, and from 1989 when 30 infestations totaling 235 ha were mapped.

The number of recently killed grand fir also declined in drainages north of Creston from Lockhart to Alkali creeks near Crawford Bay and at Crawford Creek, where mortality of more than half the trees was common in 1990. Armillaria root disease, *Armillaria* spp., was present in the recently dead trees at most sites.

Populations are likely to remain endemic. Mortality of grand fir in 1992 will likely be low and will be due mostly to infection by root disease of stressed hosts.

A balsam shoot boring sawfly

Pleroneura sp.

As forecast, sawfly populations declined to endemic levels in true firs at high elevations in the Vancouver Forest Region following three consecutive years of damage. Populations in grand fir near Creston declined and only 35% of the shoots were destroyed, and there was no damage near Nelway and Rossland where trees were lightly infested over up to 2 ha in 1990.

Balsam woolly adelgid

Adelges piceae

Active adelgid populations were found on 10-year-old and older amabilis fir at Lizzie Creek east of Lillooet Lake. Dieback and flat-topped crowns were

evident on adjacent mature and overmature trees. The area is slightly east of the quarantine zone in southwestern British Columbia. It was the second record of infested trees beyond the distribution and quarantine zones since 1987, and this is resulting in a review of the zone boundaries. Populations, however, were too low to cause any obvious damage to the regeneration.

Surveys of grand fir in the Nelson Region along the international border have not found the adelgid. Populations nearby in central Idaho increased significantly in 1990 and infested pockets of subalpine and grand fir over 24 000 ha. There was no evidence of the adelgid on two mature 'gouted' alpine fir in Nelson.

Hemlock Pests

Western blackheaded budworm

Acleris gloverana

Budworm populations in previously defoliated western hemlock near Holberg on northern Vancouver Island collapsed as forecast. Populations remained endemic in hemlock on the Queen Charlotte Islands and on alpine fir in the eastern part of the Prince Rupert Region following their collapse in 1989 and 1990, respectively. However, populations increased in the western part of the Prince Rupert Region. Alpine fir and white spruce were moderately and severely defoliated over about 1000 ha near Bare Loon Lake in the proposed Chilkoot Trail National Park and white spruce were very lightly defoliated over 10 ha in Kinaskan Provincial Park in the upper Iskut River Valley.

Western hemlock looper

Lambdina fiscellaria lugubrosa

Populations of the western hemlock looper increased greatly and defoliated mostly old-growth western hemlock in 266 patches totaling more than 50 000 ha in the Cariboo and Nelson forest regions; defoliation occured for the first time since 1984 in the Kamloops Region, and for the first time since 1964 in the Prince George Region (Map 5). This was significantly more damage than occurred in 1990, when only eight patches totaling 1115 ha were defoliated. Defoliation was mostly light and moderate and was severe on only about 10% of the area.

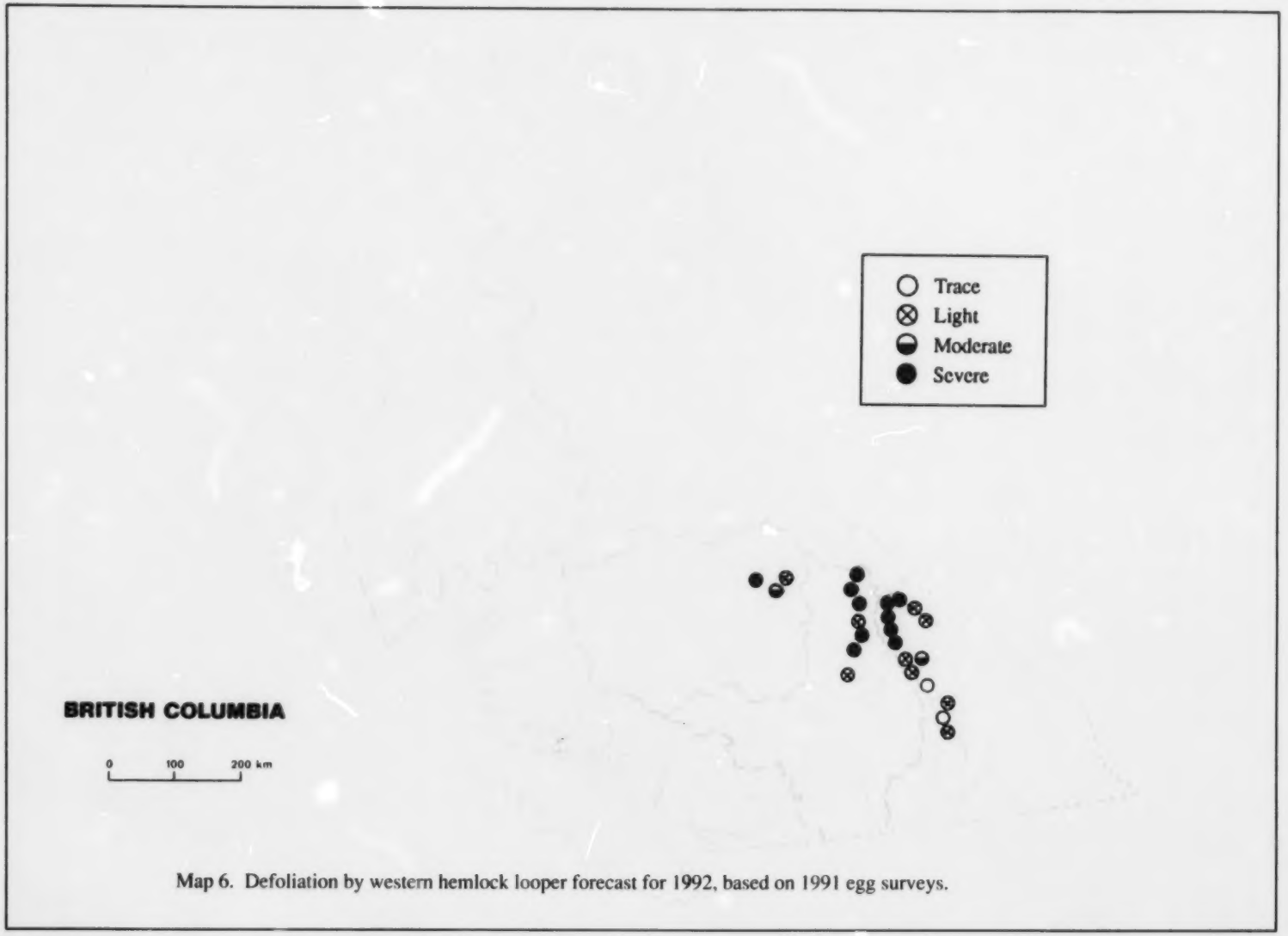
The major area of expanded defoliation was over 36 235 ha in the Kamloops Region. Defoliation was severe over 4200 ha in 10 separate infestations from Blue River to the Albreda River, near Tumtum Lake in the Adams River drainage, and along Hobson Lake in Wells Gray Provincial Park. Areas of moderate defoliation covered 17 900 ha in 21 widespread patches, and light defoliation occurred on 14 000 ha in 65 patches throughout the North Thompson and Adams river area including Wells Gray Park. One patch of dead trees, attributed to previous defoliation by the looper, covered about 140 ha near Green Bush Lake at the headwaters of the Shuswap River. Earlier infestations resulted in tree mortality and top-kill of mature hemlock.

In the Nelson Region, the area of defoliation expanded eightfold to 8225 ha; light or moderate defoliation occurred over 7150 ha and severe defoliation on 1075 ha along Revelstoke Lake from Frisby Ridge to Mica including the Albert, Downie, Script, and Bigmouth creek drainages and east of Mica along McNaughton Lake to Wood Arm.

Infestations near Quesnel and Horsefly lakes in the Cariboo Region increased to 25 areas totaling 5700 ha, up from only 200 ha in 1990 the first year of infestation. Defoliation was light over 5000 ha and moderate over the remainder on the Lynx Peninsula, east of Quesnel Lake from Killdog Creek to Stranger Lake, and from Horsefly Lake east to Bouldery Creek.

Mature hemlock and cedar were severely defoliated over about 250 ha at Hankins Creek southeast of McBride. This defoliation was the first by this defoliator recorded in the area since 1955, when patches of severe defoliation from Giscombe to McBride were recorded over 48 000 ha.

Defoliation is forecast to be severe in 1992 at 11 of 25 sites sampled in three regions in 1991. Moderate defoliation is forecast at two sites and light or trace defoliation at the remainder. In the Nelson Region defoliation is forcast to be severe at 5 of 15 sites, including Bigmouth and Downie creeks again, and at Mica, Redrock Harbour, and Goldstream River (Map 6). Moderate defoliation is forecast at Tangier River with light or trace at nine sites west and south of Revelstoke. This forecast is based on an average of 85 looper eggs (range 2-363) per sample of lichen from each site. In the Kamloops



Map 6. Defoliation by western hemlock looper forecast for 1992, based on 1991 egg surveys.

Region, severe defoliation is forecast at five of seven sample sites and light defoliation is forecast at the remainder (average 89 eggs per sample, range 15-162) in the Adams and North Thompson river drainages. In the Cariboo Region, where an average of 37 eggs were found per lichen sample (range 4-71), defoliation is forecast to be severe on the Lynx Peninsula area of Quesnel Lake; moderate defoliation is forecast at one site at Boulder Creek, but only trace defoliation is forecast at a second site.

Larval and pupal mortality from parasitism was less than 1% of the population at three sample sites north of Revelstoke. This compares with 34% in the previous infestation in 1983, which resulted in the collapse of populations in 1984.

Gray spruce looper

Caripeta divisata

Defoliation of mostly western hemlock and western red cedar, and some other coniferous species, by the looper in the western part of the Nelson Forest Region increased almost threefold to 3850 ha in 34 separate patches (Map 5), up from 1370 ha the first year of the outbreak in 1990.

Defoliation, mostly near Arrow, Slocan, Box, and Duncan lakes, was moderate over 2735 ha and light over 1115 ha. Most of the moderately defoliated patches were on the west side of Upper Arrow Lake. Elsewhere, defoliation was light in widespread scattered patches on the west side of Slocan Lake including Valahalla Provincial Park, and near Box and Duncan lakes. Damage assessments of hemlock stands severely defoliated in 1990 found 12% of the trees killed in two stands, top-kill on 70% of the trees, and dieback of the mid-crown on 22% of the trees.

Larval mortality at four sites averaged 72% (although this may in part be due to contamination), up from 27% in 1990. Mortality was caused mostly by pathogens, *Entomophaga* sp. and *Paecilomyces* sp., which should reduce populations significantly in 1992.

Larch Pests

Larch casebearer

Coleophora laricella

Larch casebearer populations in western larch stands in southeastern British Columbia increased slightly overall.

Trace to light defoliation and small patches of moderate defoliation were again common in the host range in drainages from Oliver to Cherryville and east of Osoyoos in the eastern part of the Kamloops Forest Region. Low populations continued near Sicamous where they were first recorded in 1990.

Populations increased slightly overall in the East Kootenay part of the Nelson Region, particularly near Creston where stands over 450 ha at Summit Creek and over 100 ha at Mt. Rykerts and East Arrow Creek were lightly defoliated. Defoliation in the West Kootenay was generally trace or light throughout the host range. This was less severe than the defoliation recorded in 1990.

At most of the 18 long-term parasite release study sites in the Nelson Region, and at two sites in the adjacent Kamloops Region, defoliation was trace to generally light. At sites near Castlegar and Vernon, defoliation was light and moderate, respectively, where defoliation was severe in 1990.

Larval parasitism, mostly by the introduced *Agathis pumila* and also by *Chrysocharis laricinellae*, averaged 10%, similar to parasitism levels in 1990 and 1989. Parasitism of casebearer pupae decreased slightly to 10% (range 0-48%) from 14% in 1990 (L. Humble and I. Otvos, Forestry Canada, Victoria, personal communication).

After several consecutive years of low populations attributed to the success of parasite releases, sampling of overwintering larvae to determine populations and to forecast defoliation was discontinued in 1990. More than 15 000 specimens of *C. laricinellae* or *A. pumila* have been released in the biological control program against larch casebearer from 1966 to 1987.

Larch sawfly

Pristiphora erichsonii

Populations of larch sawfly continued to decline almost to endemic levels in most previously defoliated tamarack stands in northern British Columbia, in the southwestern part of the Yukon Territory, and in exotic larch plantings in central and southwestern British Columbia, but remained endemic in western larch stands in the Nelson Region.

Tamarack at French River in the northern part of the Prince Rupert Region near the Yukon border and along the Robert Campbell Highway in the Yukon Territory were very lightly defoliated. This followed a significant decline in populations in 1990.

Small groups of larch in Stanley Park in Vancouver were lightly defoliated for the third consecutive year but less severely than in 1989, the first year defoliation was recorded by FIDS in the area. At the University of British Columbia Research Forest near Haney, declining populations lightly defoliated exotic larch for a fourth year. At Terrace and Prince George, populations were endemic following defoliation of exotic larch for three consecutive years.

Green larch looper
Semiothisa sexmaculata

Larch looper populations in western larch stands in the West Kootenay from Creston to Fauquier collapsed following patchy defoliation of western larch totaling 12 000 ha in 1990, the first year of infestation since 1977. Larval parasitism in 1990 averaged 32%, and pupal parasitism was 12%. These levels were considered too low to eliminate populations, and the number of overwintering pupae indicated light defoliation in 1991; however, populations did not develop.

Larch needle diseases
Hypodermella laricis
Meria laricis

New infections and discoloration of western larch by larch needle diseases were conspicuous and widespread throughout much of the host range in the Nelson and Kamloops forest regions for the second consecutive year. Foliage discoloration was generally moderate but with severe browning in patches up to 800 ha. These diseases have fluctuated periodically with weather conditions.

In the Nelson Forest Region, patches of western larch discolored by *M. laricis* totaled nearly 10 000 ha in about 80 separate areas scattered across the host range. Patches of severe and moderate discoloration were common, particularly in the southern part of the East Kootenay, in the Boundary TSA and in the southern parts of the Arrow and Kootenay Lake TSAs in the West Kootenay.

In the Kamloops Region, discoloration of all age classes of western larch increased throughout the Okanagan TSA, and from Canoe to Sicamous in the Kamloops Region. From 30 to 100% of immature and mature trees were severely discolored particularly on north facing slopes, at widespread locations east of Vernon, in the Shuswap River Valley, near Mabel Lake, from Canoe to Sicamous, and west of Spallumacheen.

A larch shoot miner
Argyresthia columbiana

Populations of a shoot miner, which killed new shoots of young western larch at Brewer Creek near Dutch Creek in 1990, increased significantly in 10- to 15-year-old larch in a spaced stand and killed 40% of the tips on 75% of the trees.

European larch canker
Lachnellula willkommii

There has been no evidence of this potentially damaging canker in western, alpine, eastern, or exotic larch stands in British Columbia. A native larch canker continues to be found on immature western larch only in a few widely scattered sites in parts of the Nelson Forest Region.

Multiple Host Pests

Black army cutworm
Actebia fennica

Cutworm populations generally remained at low levels in recently burned and planted sites in interior British Columbia in 1991. This was similar to population levels in the previous two years. Recently planted seedlings were lightly defoliated at only 4 of 44 sites surveyed in three forest regions. These included a site slash-burned in the fall of 1990 southeast of Prince George, two sites in the western part of the Prince Rupert Region, and one site in the eastern part of the Nelson Region. Elsewhere, larvae were common on deciduous ground cover at an additional 7 of 20 sites in the Prince Rupert Region, and at 2 of 10 sites in the Nelson Region. Moth catches at these sites in 1990 ranged from 210 to 613 (average 432).

Population declines in 1989 and 1990 were attributed to natural factors, an entomopathogen and natural parasites which reduced larval populations by up to 53% and reduced pupae by 47%. Larval mortality in 1991 was mainly due to diseases, *Verticillium* sp., *Fusarium* sp., and *Paecilomyces*. Only 8% of the larvae were parasitized, mostly by Diptera.

In the Nelson Region, cutworm larvae severely defoliated half the Engelmann spruce seedlings planted in 1991 over 10 ha at Vowell Creek in the East Kootenay. Ground cover was lightly defoliated over an adjacent 10 ha where 613 male adults were trapped in 1990. The number of pupae ranged from 10 to 50 per 1000 cm^2, which is similar to the numbers of pupae found in 1990, and which indicates continuing populations in 1992. Follow-up surveys of western larch defoliated by cutworm in 1990 found dead terminal shoots and new growth limited to the base, resulting in bushy growth. At Swan Creek on the west side of McNaughton Lake, herbaceous ground cover was also lightly defoliated where 535 males were trapped in 1990, but there was no damage to recently planted seedlings. In the West Kootenay, fireweed was lightly defoliated at one of eight sites examined north of Revelstoke, but larvae were too few to damage seedlings.

In the Prince Rupert Region, cutworm larvae lightly defoliated recently planted seedlings in two recently burned sites near Meziadin Lake in the western part of the region. Fireweed and other herbaceous ground cover were lightly defoliated at an additional 7 of 20 sites surveyed in the region, mostly in the Meziadin Lake area where 150-550 moths were trapped (average 340/trap) in 1990.

In the Prince George Region, cutworm larvae severely defoliated ground cover over 1 ha within a 400-ha recently burned and planted site at Hambone Lake southeast of Prince George. About 770 male adults were trapped at the site in 1990. There was no evidence of larval populations at an additional nine sites surveyed in 1991, where up to 572 males had been trapped last year.

Based on the numbers of male adults in pheromone-baited sticky traps, cutworm larvae could pose a threat to seedlings planted in 1992 in areas that were slash burned in 1990-91. More than 600 males were trapped at 6 of 65 trap sites in parts of three regions. All six sites were in the Prince Rupert Region, the highest catch (1167 moths) occurred near Chapman Lake north of Smithers. A predictive warning system linking moth catches with subsequent defoliation of seedlings and vegetation is currently in press (R. Shepherd, Forestry Canada, Victoria, personal communication).

Rhizina root disease

Rhizina undulata

Fruiting bodies of Rhizina root disease were generally less numerous and widespread and seedling mortality was significantly lower than in 1990 in parts of the Nelson and Prince Rupert forest regions. This was the fourth and lightest year of seedling mortality caused by this disease in the Pacific and Yukon Region.

Seedling mortality in the Prince Rupert Region in 1991 declined significantly from an average of 13% in 1990. This was due to planned delays in planting where fruiting bodies had been present in 1990 or 1989. Fruiting bodies were found in 12 of 15 previously burned areas in the western part of the region but only 2% of the seedlings were infected at two of the three sites planted this year. Fruiting bodies and very small numbers of recently killed seedlings were found in 2 of 18 sites surveyed in the eastern part of the region.

In the Nelson Region, 1 to 30% (average 12%) of the seedlings were killed at 5 of 10 recently burned and planted sites surveyed in the West Kootenay, compared with 27% of the seedlings killed in four sites in 1990. Fruiting bodies were common in an additional unplanted area, and at one of five planted sites in the eastern part of the region, but seedlings were not affected.

Year-old sporophores were still present in part of a burned and planted site west of Clearwater in the Kamloops Region where seedling mortality occurred in 1990, but none was found at another 10 recently burned areas.

The presence of new fruiting bodies in parts of two forest regions in 1991 could provide inoculum to infect some recently burned adjacent sites in 1992. Delay of planting where fruiting bodies are present could reduce losses.

Pests of young stands

More than 250 young 2- to 25-year-old natural and planted conifer stands established or treated under the first Canada/B.C. Forest Resources Development Agreement were surveyed in British Columbia in 1991. This was part of a continuing study to identify major pests and environmentally related problems and their impact on young stands.

At each location, at least seven trees were examined in each of at least 10 circular plots. In total more than 28 000 trees were examined. Pines were the major component in about 41% of the sites, spruce in 20%, Douglas-fir in 20%, hemlock in 3%,

Table 2. Number of young stands by region and species examined in British Columbia in 1991

Region	Species					
	Total	Pine	Douglas-fir	Spruce	Hemlock	Other[1]
Cariboo	27	11	8	4	-	4
Kamloops	44	26	1	10	-	7
Nelson	46	17	14	9	-	6
Prince George	53	29	1	19	-	4
Prince Rupert	40	20	-	9	-	11
Vancouver	39	-	27	-	5	7
Q.C. Islands	3	-	-	-	3	-
Total	252	103	51	51	8	39
(%)		(41)	(20)	(20)	(3)	(16)

1 Includes plots in which the major component is not listed above, e.g., western larch, western red cedar, true firs, or where species are equal components.

true firs, cedar, larch and other species including trembling aspen and poplar comprised the remainder (Table 2).

About 60% of the 252 stands surveyed were either free of pests or contained only insects or diseases of no consequence. The remaining 40% contained pests which caused significant damage including tree mortality, but usually less than 10% of the trees were affected. Locally significant and damaging were root diseases, terminal and root collar weevils, and stem rust cankers. Less significant but widespread problems included the effects of year-old and new climatic injury, mammal feeding, and infection of new and older needles by native diseases.

Tree mortality caused by root diseases including Armillaria, *Armillaria* spp., and blackstain, *Leptographium wageneri*, averaged 4% (range 1-12%) of the conifers in 8% the stands examined, mostly in the eastern part of the Nelson Forest Region.

Spruce weevil, *Pissodes strobi*, infested 8% (range 1-46%) of the terminals in 33% of 51 spruce plantations particularly in the western part of the Prince Rupert Region, where terminal leader mortality was higher than average at 12% in five stands. Current attack of 9 and 29% of the terminals was found at two sites in the eastern part of the Cariboo Region. An average of 4% (range 1-15%) of the terminals in 7% of the immature lodgepole pine plantations in five regions were attacked and killed by lodgepole pine terminal, *P. terminalis*, in 1991. The highest incidence of this weevil was in the eastern part of the Prince Rupert Region. An average of 5% (range 1-32%) of the immature lodgepole pine in 24% of the pine plantations were infested by Warrens root collar weevil, *Hylobius warreni*. The highest level of damage was partial basal girdling of 32% of the trees at Andimaul Creek in the eastern part of the Prince Rupert Region. Mortality of immature lodgepole pine in nearby areas in previous years reached 15% and more than 75% were partially girdled. In the Prince George Region, 3% (range 1-14%) of the trees were infested in 13 plantations.

Stem and branch diseases including western gall rust, *Endocronartium harknessii*, blister rusts, *Cronartium* spp., and *Atropellis* cankers, *Atropellis* spp., were common in pine plantations surveyed, but on average these diseases infected less than 5% of the trees. Western gall rust, *Endocronartium harknessii*, was common in 60% of the stands but infected an average of only 4% (range 1-12%) of the trees, and generally there was little impact on stocking levels. Blister rusts, *Cronartium* spp., infected an average of 5% (range 1-12%) of the immature lodgepole pine at 17 sites in parts of three forest regions, mostly west of Prince George and in the eastern part of the Prince Rupert Region. Infections were primarily on stems but tree mortality, frequently the result of perennial stem cankers, was generally less than 1%. White pine blister rust, *C. ribicola*, infected an average of 2% (range 1-6%) of the white pine in seven plantations in three forest

regions, but most of the infections were in the Vancouver Region. Atropellis stem cankers, *Atropellis* spp., infected 5% of the 25-year-old lodgepole pine in 15 stands mostly in the Prince George Region and the eastern part of the Prince Rupert Region.

Buds killed by recent early and late frosts and cold winds often resulted in multiple tops. This type of damage affected 15% (range 1-84%) of the conifers in about 75% of the young stands mostly in the Cariboo, Prince George, and Prince Rupert regions.

Feeding by a variety of mammals debarked stems and branches of conifers in 37% of the young stands surveyed. However, stocking levels were not seriously reduced except occasionally by porcupines and voles (see 'Mammal damage' page 27).

Foliar diseases infected and discolored both new and old needles of conifers in about 30% of the young stands surveyed. Most moderate and severe infections resulted in premature needle loss, but caused little change in vigor or form. The foliar diseases were most common on pines. The most common disease on pines was a needle cast, *Lophodermella concolor*. Less common were red band needle disease, *Dothistroma (Scirrhia) pini*, and *Elytroderma deformans*. Fir-fireweed rust, *Pucciniastrum epilobii*, discolored new foliage on up to 45% of the true firs in 20 plantations, most of them north of Prince George.

Lodgepole pine dwarf mistletoe, *Arceuthobium americanum*, infected young lodgepole pine in only two plantations. The stems and branches on 2% of the 14-year-old trees at Mackin Creek, west of Williams Lake in the Cariboo Region, were infected due to the proximity of severely infected overstory. One percent of the pine were infected at Whistle Creek near Hedley in the southern part of the Kamloops Region.

The most common pest of Douglas-fir was Cooley spruce gall adelgid, *Adelges cooleyi*, although it did not significantly affect tree growth and vigor or tree form. Also common but of little consequence were spruce gall adelgid, *Pineus* sp., which was common in 60% of the spruce stands and giant conifer aphid, *Cinara* sp., which was found on 3% (range 1-9%) of the conifers at nine sites.

Defoliator larvae were common but they were too few to cause significant damage. These included western spruce budworm, *Choristoneura occidentalis*, and 2-year-cycle budworm, *C. biennis*.

Lodgepole pine, some Scots pine, Siberian larch, and Norway spruce seedlings planted in 1986 were examined at four sites in the Prince George Region and at one site in the Yukon Territory as part of a cooperative international survey with Svenska Cellulose of pest losses on different provenances. Bud mortality caused by frost, snow, ice, and cold winds resulting in multiple tops and bushy form was common at three sites in the northern part of the Prince George Region. An average of 35% (range 20-45%) of the Siberian larch were affected at three sites, 5 and 80% of the lodgepole pine at each of two sites, and 90% of the Norway spruce were affected at one site near Fort Nelson. Western gall rust, *Endocronartium harknessii*, infected stems and branches on 5% (range 1-10%) of the trees at all four plots in the Prince George Region. Stem cankers of blister rust, *Cronartium coleosporioides* and *C. comandrae*, infected 12% of the lodgepole pine at Nation Bay near Mackenzie, where Warren's root collar weevil, *Hylobius warreni*, also girdled and killed 3% of the trees this year. Stalactiform rust also infected 2% of the lodgepole pine at sites near Terrace and Dease Lake in the western part of the Prince Rupert Region. Increased numbers of northern pitch twig moth, *Petrova albicapitana*, lightly infested 2% of the stems of trees in plots near Mackenzie and Fort Nelson. Increased populations of gouty pitch midge, *Cecidomyia piniinopis*, populations infested an average of 6% (range 1-10%) of the new shoots on about 16% of the pine near Fort St. James, but none was infested near Fort Nelson where 1% of the trees were infested last year. All the Siberian larch and Norway spruce at the plot near Fort Nelson again had only trace defoliation from a few larvae of eastern spruce budworm, *Choristoneura fumiferana*, which is epidemic in the area. About 10% of the 1-year-old needles on 30 to 40% of the lodgepole and Scots pine at the Teardrop Road plot near Fort St. James were chlorotic, which may have been due to a nutrient deficiency.

About 22% of the Siberian larch and 6% of the lodgepole pine in the Takhini Forest Reserve plot near Whitehorse have been killed, mostly by planting shock and by successive years of winter damage. Stems on an additional 60% of the pines around the plot perimeter were clipped off by snowshoe hares, *Lepus* sp., leaving only the first whorl on about 25% of the trees. Adjacent larch, which had been damaged by feeding, average only 10 cm in height after five growing seasons.

Seed orchard and nursery pests

Surveys of foliar insects and diseases on seed orchard trees continued in 1991. Assessments of

cone and seed insects and diseases in seed orchards were discontinued in 1989.

Thirteen coastal seed orchards were surveyed in 1991. Douglas-fir was the most common tree species in nine orchards, western hemlock the most common at six orchards, amabilis fir at four, and poplar at three; western red and yellow cedars, Sitka spruce, lodgepole and white pine, and noble fir were in only one or two seed orchards.

The most common pest on Douglas-fir was Cooley spruce gall adelgid, *Adelges cooleyi*, which lightly and sometimes moderately infested most Douglas-fir in seven of nine orchards and 1 to 10% of the tips on 75 to 80% of the spruce at two orchards. A very few larvae of western spruce budworm, *Choristoneura occidentalis*, were common in three orchards, but no damage was observed. Balsam woolly adelgid, *Adelges piceae*, was common on amabilis fir in two of four orchards, and balsam twig aphid, *Mindarus abietinus*, deformed 20% of the needles and twigs on about half of the amabilis fir at one orchard. Sitka spruce at two orchards were lightly infested by *A. cooleyi*, but not by green spruce aphid, *Elatobium abietinum*, which had infested 70% of the trees at three orchards in 1990. There was no additional damage to yellow cedar by a gall midge which declined in 1990 due to parasitism after three years of severe damage in two orchards. Hemlock woolly adelgid, *Adelges tsugae*, remained endemic in four orchards and lightly infested western hemlock at two orchards. Yellow blisters on poplar leaves caused by *Taphrina populina* were common on up to 20% of the leaves on up to half the trees at three orchards.

In forest nurseries, several thousand western red cedar seedlings were killed by increased severe infection by a leaf blight, *Didymascella* (Keithia) *thujina*. Seedling root rots, *Fusarium* sp. and *Pythium* sp., and shoot blight caused by *Botrytis* sp., were less common on nursery stock than in 1990. *Sirococcus strobilinus*, was not found on western hemlock seedlings and seeds in 1991 in British Columbia, where it was found on seedlings for the first time in 1990.

Forest tree seed collected for international trade in British Columbia and Yukon Territory is certified under the Organization for Economic Cooperation and Development (OECD). In 1991 a total of 700 hectolitres of cones of 10 coniferous species (mainly Sitka spruce with lesser amounts of pines, spruce, and firs) and 10 hectolitres of alder were certified for export. The value of the seed extracted from these cones exceeds $750 000.

Root diseases

Armillaria spp.
Inonotus tomentosus
Leptographium wageneri
Phellinus wierii

Surveys of ten mature stands in two drainages in the Engelmann Spruce-Subalpine Fir (ESSF) biogeoclimatic zone in the East Kootenay part of the Nelson Region found that 42% of the trees had been killed by root diseases or had symptoms of infection. An additional 32% of the trees were infected but did not show external symptoms of infection. Recent mortality of Douglas-fir killed by Armillaria root disease, *Armillaria ostoyae*, in a park near Kamloops resulted in stand openings near campsites. Mortality of mature lodgepole killed by blackstain root disease, *L. wageneri*, was common in parts of the North Thompson River Valley. Mature and immature Douglas-fir were killed by root diseases at widespread locations throughout the Vancouver Region.

In ten representative stands in the East Kootenay, tree mortality caused mostly by *Inonotus tomentosus* and to a lesser extent by *Armillaria ostoyae*, was highest in Engelmann spruce and lodgepole pine in the middle fork of the White River drainage where 96% of the spruce and 85% of the pine were dead or dying. The remaining 4% of the spruce were infected but showed no symptoms. Nearly half (46%) of the mature lodgepole pine at Angus Creek, one of six sites surveyed in the St. Mary River drainage, were dead or dying and an additional 51% were infected but showed no external symptoms. Additionally, surveys of mature lodgepole pine at Quartz Creek west of Golden found that 10% of the trees had been killed and an additional were 6% infected by blackstain root disease, *L. wageneri*. These infections were a significant extension of the eastward range of previously known areas of infected pine, and were associated with trees attacked by pine engraver beetle, *Ips pini*. Elsewhere in the Nelson Region, 60- to 80-year-old grand fir and Douglas-fir in pockets along the Pend-d'Orielle Valley were recently killed, mostly by *Armillaria* root disease and to a lesser extent by blackstain root disease. *Armillaria* root disease also killed 35% of the lodgepole pine in a 1987 plantation at Skeff Creek west of Grand Forks, where blackstain root disease was also present.

In the Kamloops Region, recent mortality of mature lodgepole pine, Engelmann spruce and Douglas-fir infected by *Armillaria* root disease

resulted in stand openings adjacent to campsites at Paul Lake Provincial Park. Elsewhere, blackstain infected and killed about 20% of the mature pine in patches west of Darfield in the North Thompson River Valley.

Mature and immature Douglas-fir killed recently by *Phellinus* root disease were common in the Vancouver Region in the Chehalis River drainage near Squamish, and at Harrison Lake, Mission, and Gibsons. Numerous recently dead standing mature trees occurred in pockets near stumps and windthrow throughout a heavily used recreational campsite near Roberts Creek on the Sunshine Coast. Armillaria root disease killed up to 25% of the semimature and young trees in small patches in six surveyed areas in the Vancouver Region. The highest mortality was at Mowhokam Creek near Boston Bar, and occurred also, but less commonly in the University of British Columbia and Seymour demonstration forests, in the Capilano watershed, and near Sechelt and Powell River.

Mammal damage

Feeding damage to recently planted coniferous seedlings and immature trees by a variety of mammals increased significantly in 1991 in parts of six forest regions and Yukon Territory.

Voles

High numbers of meadow voles, *Microtus* sp., killed up to 20% of the recently planted stock in a plantation on the east side of Babine Lake in the Prince Rupert Region. Damage was common but less severe at an additional eight sites. This occurred during the winter and followed significant population increases in 1990. At Salvus Creek west of Terrace, 39% and 15% of the seedlings were killed or partially girdled at each of two plantations. Elsewhere in the region, stems were partially girdled and leaders and laterals were clipped on a small number of stems at one site, and roadside lodgepole pine and deciduous seedlings were killed or stripped at two sites between Meziadin Lake and Cranberry River.

About 24% of the spruce seedlings were girdled and killed in a recently planted site at Ensign Creek north of Golden in the Nelson Region. None was damaged at Redding Creek west of Kimberley where groups of seedlings were killed in 1990.

Increased vole populations in parts of the Cariboo Region killed about 40% of the lodgepole pine and some Douglas-fir seedlings in a planted area at Leeches Lake west of Williams Lake. Recently planted seedlings in the Kimsquit River drainage north of Bella Coola were killed by voles. This was the first record of significant damage in the area.

At Callaghan Creek near Squamish, about 75% of the Douglas-fir planted in 1989 were dead when surveyed in 1991. Mortality was attributed to debarking by voles in 1989-90. There was no evidence of new feeding at Twin One Creek south of Pemberton, where seedlings were debarked and killed in 1990.

Porcupines

Young and semimature conifers continue to be killed by porcupines, particularly in the western part of the Prince Rupert Region where patches of stem and branch bark have been chewed annually. This has been a significant factor in reducing stocking levels particularly in spaced lodgepole pine and western hemlock stands. In 1991 tree mortality or debarking was recorded in 50 widely scattered areas totaling about 725 ha. About 33% of the mostly dominant and codominant conifers were top-killed and an additional 9% were partially girdled in a 15-year-old plantation at Shames River west of Terrace. An average of 64% of the amabilis fir, 28% of the hemlock, and 6% of the Sitka spruce had dead tops. Northwest of Terrace, 10% of the immature to semimature alpine fir and western hemlock were killed over 100 ha at Luncheon Creek and 1% were killed over 25 ha at Erlandsen Creek. Half the trees at both sites were top-killed. At the south end of Lava Lake, about 30% of the naturally regenerated lodgepole pine were totally or partially girdled in one small patch. About 10% of 30-year-old codominant trembling aspen in a 5-ha patch at Sedan Creek west of Kitwanga were partially girdled but not yet killed.

Squirrels

Feeding by increased squirrel populations in the Cariboo Region resulted in highly visible branch tip mortality on lodgepole pine. One to thirty 'flagged' branches per tree in pockets of 0.2 to 0.5 ha were common in the southern and western parts of the region. Feeding on healthy and dwarf mistletoe-infected lodgepole pine was common, particularly from 70 Mile House to Lac la Hache and from Anahim to Tatla Lake.

An estimated 55% of the recently planted lodgepole pine seedlings were killed by ground squirrels over 55 ha near Barriere Mountain in the

Kamloops Region. An additional 30% were killed over 5 ha near Coldscaur Lake in the North Thompson River Valley, where seedling mortality occurred in 1990.

Squirrels debarked and killed 10% and damaged a further 80% of the young spaced lodgepole pine at a site at Bobtail Creek, southwest of Prince George.

Partial branch girdling of immature lodgepole pine was more common than in 1990 in parts of the Yukon Territory. About five branch tips were debarked on 10% of the trees, usually in dense stands from Watson Lake in the Yukon Territory to Swift River in the northern part of the Prince Rupert Region, and to a lesser extent near Boya and Dease lakes. Hares clipped the stems of conifers along road edges near Whitehorse, the south end of the Canol Road, and near Johnsons Crosssing.

Climatic injury

Following severe discoloration by strong cold winds in early 1989, recovery of most conifers in parts of six forest regions continued. There was no increase in mortality of hemlock and cedar near Bella Coola and mature lodgepole pine south of Fernie. Winter damage to conifers was widespread in the Yukon Territory for a third consecutive year.

There was little evidence of permanent damage to conifers in the eastern part of the Cariboo Region and near Bella Coola and along Burke Channel to King Island where a new flush occurred in late 1989. Signs of recovery had been evident in 1990. However, small patches of tree mortality and bud mortality were common over 250 ha west of Lac La Hache. Recovery of previously discolored conifers was common in most regions and was evident in the following areas: in the Kamloops Region, particularly in the Highland Valley, in Wells Gray Provincial Park, and Vavenby; in the eastern part of the Nelson Region, in the Flathead and Elk river drainages, the Wigwam, Couldrey, and Kishinena creek valleys, and in the Bush River Valley and in Glacier National Park; east of Prince George to McBride, at Tumuch Creek, along the Bowron River Valley, and in the Torpy River drainage; in the Prince Rupert Region along the Skeena River Valleyand near Fulton Lake in the eastern part of the region.

Climatic injury to conifers in 1991 was most severe and widespread in the Yukon Territory. Low temperatures, often accompanied by strong winds, caused needle discoloration, terminal and branch dieback and occasionally tree mortality of spruce and to a lesser extent other conifers. This has occurred for at least five consecutive years at widespread locations throughout the Yukon Territory. Most damage was along Little Atlin Lake, along the Alcan Highway from Burwash Landing to Beaver Creek, and along the Klondike Highway north of Stewart Crossing to Carmacks. About 5% of needles on immature lodgepole pine at Takhini were discolored, and 10 to 80% (average 40%) of the older needles were 'winter flecked' for 5 km near km 1367 on the Alcan Highway. An average of 20% of the year-old alpine fir needles were killed over 5 ha north of Johnstons Crossing and 10% of the new buds on tamarack along the Campbell Highway north of Watson lake were killed by late frost.

Roadside conifer mortality

New tree mortality, crown and branch dieback, and foliage discoloration of conifers along paved highways and access roads declined overall in the Cariboo, Nelson, and Prince George regions but increased in localized areas of the Kamloops Region.

Damage caused by a combination of site, salt injury, and moisture stress was less common than in 1990 in the Cariboo Region, where Douglas-fir, lodgepole pine, and spruce had been severely affected along many highways in 1989. Recent damage occurred in about 150 widely separated patches along most major highways in the region, and at a municipal park at Williams Lake.

Recent tree mortality and foliar discoloration of Douglas-fir and some lodgepole pin was minimal in the East Kootenay. Similarly, discolored roadside cedar, pine, Douglas-fir, and spruce were less numerous in the West Kootenay from Nancy Greene Lake to Grand Forks, from Rock Creek to Beaverdell, and along the Christian Valley Road.

There was little or no discoloration of roadside conifers by winter salt in the Prince George Region where such damage was widespread in 1989-1990.

Douglas-fir as well as lodgepole and some ponderosa pine adjacent to roads in parts of the Kamloops Region were killed, severely discolored, and occasionally predisposed to attack by bark beetles by winter salt accumulations. Most affected trees were in small widespread patches near Anarchist Mountain, Westwold, Carquille, and in Fountain Valley near Lytton.

Acid rain monitoring

There was no change attributable to acid rain in the condition of trees and ground cover at 15 permanent sample plots across British Columbia monitored in

1991. Mortality from causes other than acid rain averaged 3% of the trees in seven plots mostly in the Vancouver Region. Mortality was attributed to suppression, to the root disease *Armillaria ostoyae*, or to blowdown.

Plots will be monitored closely because of concerns about potential acid rain and long-range transportation of air pollutants. However, to date there is no scientific proof of damage caused by acid rain in western forests.

Deciduous and Ornamental Tree Pests

Tent caterpillars

Malacosoma spp.

Defoliation of trees and shrubs by forest tent caterpillar, *Malacosoma disstria*, in parts of three forest regions covered about 131 000 ha (Map 5). As predicted, this is about half the area affected in 1990. Defoliation was less widespread near Prince George and in the Peace River area, but increased near McBride, in the eastern part of the Cariboo Region, and in the northern part of the Kamloops Region. Populations of northern tent caterpillar, *M. californicum pluviale*, increased slightly in the Prince Rupert Region and defoliated 72 separate stands over 4260 ha near Terrace.

Declining forest tent caterpillar populations northwest and south of Prince George defoliated trembling aspen and, to a lesser extent, other deciduous trees in 69 infestations over about 81 000 ha. Defoliation was mostly light and moderate, although there were patches of severe defoliation around and within Prince George. Aspen were defoliated in some areas for the eighth year. Declining populations in the Peace River area defoliated aspen in 37 areas over 4800 ha near Taylor, Farmington, and Pouce Coupe, a decline from the 35 600 ha mapped in 1990. The area of aspen defoliated near McBride increased to over 6500 ha, up from 4450 ha in 1990 and 260 ha in 1989 when the infestation began.

Trembling aspen were severely defoliated in the Cariboo Region in 155 patches totaling 14 185 ha, a threefold increase from 1990. Defoliation was mostly severe near Bridge and Canim lakes east of 100 Mile House, near Quesnel and Horsefly lakes, and from near Horsefly to Williams Lake. Defoliation had occurred in some of these areas for four consecutive years. Areas of defoliation in the Kamloops Region doubled to 6500 ha in 38 separate patches. Some stands from Barriere to Avola and in Wells Gray Provincial Park, were defoliated for a third year, but populations declined near Salmon Arm, Skimikin, and Tappen where there was no significant defoliation. Populations collapsed in the Nelson Region, as predicted, and remained endemic in the Vancouver Region near Chilliwack.

Defoliation of trembling aspen, cottonwood and other deciduous trees and shrubs is forecast to continue in 1992 in most recently infested stands, but the extent and intensity of defoliation will generally decline. The average number of new egg masses declined at 15 sites in the Prince George Region to three per tree (range 1-16), down from 17 in 1990 and 38 in 1989. Generally light defoliation is forecast near Prince George and in the Peace River area, but moderate and severe defoliation is forecast near McBride and Tete Jaune where an average of 11 new egg masses per tree (range 6-16) were found. More than 10 masses per tree usually indicate severe defoliation. In the eastern part of the Cariboo Region, where an average of 13 egg masses were found per tree (range 1-49) severe defoliation is forecast at two sites, moderate defoliation at two sites, and light defoliation is forecast at three sites between Horsefly, Likely, and Quesnel. Defoliation is expected to continue in adjacent parts of the Kamloops Region.

Larval parasitism and disease at nine sites in two regions averaged 21%. The increased level of parasitism (there were less than 5% in 1990) contributed to a decline of populations in some areas.

Increased northern tent caterpillar populations defoliated mostly black cottonwood over 4260 ha in more than 70 separate patches in the western part of the Prince Rupert Region, up from 3200 ha in 1990. About 25% of the area was severely defoliated, and 45% was moderately defoliated. Defoliation was more widspread near Terrace and in patches in the Skeena River Valley from the Kasiks to the Shames rivers. Defoliation in the Wedeene River Valley, which occurred for the first time in this outbreak, was mostly severe.

Large aspen tortrix

Choristoneura conflictana

Trembling aspen were defoliated by large aspen tortrix in parts of the Prince George Forest Region and in southwestern Yukon Territory, in some areas for the third consecutive year. In the Prince George Region defoliation was mostly severe over about 18 000 ha, up slightly from 16 465 ha in 1990. About 45 separate patches of defoliation extended from Mackenzie to Fort Ware and along the Alaska Highway from Fort St. John to Pink Mountain and west of Fort Nelson at Steamboat Mountain. In the Yukon Territory, defoliation was generally more widespread but less severe than in 1990, particularly near Whitehorse. Defoliation was mostly light but occasionally severe in patches from Teslin west to Takhanne River Crossing.

Larval predation and parasite eggs on 5% of the larvae in defoliated stands in the Yukon is still rare but indicates a potential for partial reduction of populations in 1992. Parasitism levels in 3- and 4-year-old infestations are expected to increase.

Gypsy moth

Lymantria dispar

About 72 adult male gypsy moths were trapped in 17 areas in British Columbia in 1991. This compares with 121 males in 16 areas in 1990. More than 8000 sticky traps were monitored throughout British Columbia in 1991, the sixteenth year of a cooperative program with Agriculture Canada (Plant Health), FIDS, and the British Columbia Forest Service.

Twelve of the 72 males have been confirmed by DNA analysis to be of the Asian strain, and 13 are suspected to be the Asian strain of gypsy moth. This is the first known capture of this strain in North America. Most were trapped in the Vancouver area in the vicinity of the Pacific National Exhibition, and some were trapped in or near Stanley Park. Most of the remaining 47 males, likely of the European strain, were trapped at Parksville, Colwood, and the lower mainland.

For the fifth consecutive year male moths were caught near Parksville (7), and for the third consecutive year in West Vancouver (2), Vancouver (1), and the Saanich Peninsula (1). Catches were made for the second consecutive year at Victoria (1), Colwood (5), Coquitlam (2), and Comox (3). New catches were made at Saltspring Island (3), Courtenay (3), Lynn Valley (7), Langley (3), Surrey (6), Aldergrove (1), Richmond (3), and at Golden Ears (1) and Alice Lake (1) provincial parks.

Only one male was caught on the Saanich Peninsula north of Victoria International Airport where high trap catches (96 males) and numerous egg masses (37) were found in 1990. These high numbers of adult males trapped in 1990 prompted aerial (113 ha) and ground (40 ha) applications of *Bacillus thuringiensis* var. *kurstaki* (Foray 48B) in late April and May 1991 in an apparently successful eradication effort. Only seven males were captured at Parksville where *Bacillus thuringiensis* was applied aerially (over 85 ha) and on the ground (over 7.5 ha) in 1990.

The captures at Golden Ears and Alice Lake provincial parks were in 2 of 305 traps set out by FIDS in 266 forested recreation areas in national and provincial parks, commercial campgrounds, and near military bases beyond the lower mainland and major towns.

Birch leaf miners

Lyonetia sp.
Fenusa pusilla
Profenusa thomsoni
Bucculatrix canadensisella

Discoloration of native birch, particularly in the Nelson Forest Region, by a leafminer, *Lyonetia* sp., remained at very low levels following a significant decline in 1990. Populations also declined at Terrace. Discoloration by *Lyonetia* sp., *Profenusa thomsoni*, and *Fenusa pusilla* was less severe and widespread in the Vancouver Region where popualtions had increased in the two previous years. Populations also declined at Smithers, and in Prince George where trees had been discolored for up to five consecutive years.

Populations of amber-marked birch leafminer, *Profenusa thomsoni*, declined in the West Kootenay from Shelter Bay to Goldstream River north of Revelstoke, and near Castlegar, and on ornamental birch in Prince George. There were only very small populations in birch trees in Fort St. James that were lightly discolored by birch leaf miner, *Bucculatrix canadensisella*, in 1990.

Satin moth

Leucoma salicis

Satin moth larvae were less numerous in the south Okanagan, following an increase in 1990, but larvae were common again in small numbers near Golden. None was seen near Chilliwack following their collapse in that area in 1990.

Populations of satin moth in cottonwood near Brookmere in the Okanagan Valley declined

significantly following severe defoliation over 5 ha in 1990, the first recorded infestation in the area since the mid-1960s. Small numbers of larvae, but too few to cause significant defoliation, were again common on aspen at a golf course near Golden near stands previously defoliated by forest tent caterpillar. Increased numbers of adults were common in the North Thompson River Valley in the Kamloops Region in areas near aspen stands defoliated by forest tent caterpillar from Barriere to Avola.

Western winter moth

Erannis tiliaria vancouverensis

Populations of western winter moth in the Vancouver Region generally remained at low levels following their collapse in 1990, but they defoliated broadleaf and vine maples and other deciduous hosts north of Spuzzum in the Fraser Canyon. Populations in the West Kootenay were also at low levels and there was no apparent defoliation.

Deciduous hosts at Alexandria Bridge Provincial Park were moderately and severely defoliated over about 20 ha, which was the only defoliation visible in the Vancouver Region in 1991. Small numbers of larvae were common between Hope and Boston Bar and near Cultus Lake and Emory Creek provincial parks, but there was no visible defoliation. A nuclear polyhedrosis virus (NPV), historically the cause of population declines, was prevalent at Cultus Lake Provincial Park in 1989, 1990, and 1991, and at Sasquatch Provincial Park in 1989 and 1990.

There was no evidence of populations which lightly defoliated trembling aspen in the West Kootenay for the first time in 1990 near Fruitvale, from Castlegar to Trail, and on birch near Beaver Falls.

Winter moth and Bruce spanworm

Operophtera brumata and *O. bruceata*

Winter moth populations declined in the lower mainland following two years of increase, and also declined on southern Vancouver Island following an increase in 1990, the first in six years. Bruce spanworm populations were less common in the lower mainland and the Fraser Valley where populations increased slightly in 1989 and 1990. Larvae were also less common in trembling aspen in the Peace River area that were defoliated by declining populations of forest tent caterpillar, *Malacosoma disstria*, and large aspen tortrix, *Choristoneura conflictana*.

Declining winter moth populations this year caused very little defoliation of birch stands near Highway 99 and the New Westminster Highway, and in scattered fruit and other deciduous trees from Ladner to Surrey, where defoliation was moderate and severe in 1990. Very light defoliation occurred at widely scattered areas throughout Vancouver, White Rock, Richmond, and parts of the upper Fraser Valley which were first defoliated last year. On southern Vancouver Island, where defoliation of deciduous trees, mainly Garry oak, has been greatly reduced by the introduction of parasites, winter moth was common but not damaging in a small number of patches, which was similar to 1990.

A native defoliator, Bruce spanworm, was often associated in low numbers with winter moth on broadleaf and vine maples on the lower mainland and the Fraser Valley, but defoliation was minimal. Larvae were less common in trembling aspen defoliated by forest tent caterpillar and large aspen tortrix in the Peace River area of the Prince George Region.

Parasitism of winter moth at six sites by introduced parasitoids averaged 57% (by *Cyzenis albicans*, a parasitic fly), and 10% (by *Agrypon flaveolatum*, a parasitic wasp).

Jumping gall wasp

Neuroterus saltatorius

Discoloration and premature loss of foliage caused by the gall wasp on Garry oaks in the Victoria area increased for a sixth consecutive year. A survey of populations and damage on Garry oaks in the Capital regional district, in cooperation with local municipalities, found a significant expansion of the infestation. Defoliation was severe and widespread from Cattle Point in Oak Bay to William Head in Metchosin and north to Mount Newton near Sidney. Populations were found in low numbers for the first time on Salt Spring and Galiano Islands.

Parasitism of the jumping gall wasp ranged from 0 to 30% but was too low to effectively reduce populations, which are forecast to continue in 1992.

An oak leaf phylloxeran

Phylloxera sp. *nr. glabra*

Defoliation of Garry oak by the phylloxeran ranged from 25 to 100% of the foliage on about 10% of the trees in widely scattered patches throughout the Capital regional district. Foliage discoloration and subsequent defoliation by the introduced phylloxeran

(an aphid-like sucking insect) generally occurs on the same trees each year, which progressively reduces tree vigor. Predators of the phylloxeran were common but too few to effectively reduce populations.

Apple ermine moth

Yponomeuta malinella

Defoliation of apple trees was less widespread and less severe in mainland areas of the Vancouver Region in 1991. This decline was predicted in 1990 when there were fewer larvae and pupae than in previous years. Widespread severe defoliation was first recorded in the region in 1989. The cause of the decline has been attributed to natural factors including climate.

An introduced pest, the ermine moth was first detected in British Columbia in 1981 in a nursery on Vancouver Island. Larvae have since been detected on native crabapple and on neglected apple trees throughout much of the lower mainland, on east coastal areas on Vancouver Island, and in the drier parts of the Thompson and Shuswap river valleys from Lytton to Little Fort and Malakwa.

Populations are expected to decline further in 1992 in most previously infested areas, paticularly in the Vancouver Region. This prediction is based on the reduced number of larvae found in 1991.

Pear thrip

Taeniothrips inconsequens

Pear thrips were found for the first time in British Columbia in 1989, and were again found in 1990 on broadleaf maple near the University of Victoria. Populations were very low and there was no significant damage. None was found elsewhere during surveys of broadleaf and vine maples in the Vancouver and Nelson regions in 1990, and none was found in 1991.

A diminutive sucking insect, hardly visible to the naked eye, pear thrips were introduced to North America where it was first found in 1904. They have since spread to most of the United States. Pear thrips caused severe defoliation of sugar maple in northeastern states in 1988, and this prompted surveys across Canada in 1989-90.

Dogwood leaf blight

Discula (= Gloeosporium) destructans

Severe foliar infection and branch dieback of native and some planted dogwoods was widespread throughout the host range in the Vancouver Forest Region for the second consecutive year. Wet spring weather for at least three years has resulted in cumulative mortality of lower branches, and severe discoloration of most of the crown was common. Tree mortality has been limited to single trees at widespread locations, but mortality has increased where severe infections reoccur.

New Records of Occurrence and Distribution

Twenty new disease collections were recorded in the region in 1991. Most were relatively minor foliage or bark disorders or saprophytes. Six collections were new records within either British Columbia or the Yukon Territory. An additional 14 diseases were recorded for the first time on new hosts; eight on conifers and six were found on deciduous trees and shrubs.

One insect collection was a new species, three collections represented significant extensions of their known distributions within the region, and a fourth collection was a first record in the insectary collection. A budmoth, *Clepsis* sp., introduced to North America from Europe, was collected in small numbers for the first time in British Columbia on white spruce in a nursery at Abbotsford. A jumping gall wasp on Garry oak, *Neuroterus saltatorius*, was collected at widespread locations throughout the Greater Victoria area, which is a significant extension of its previously known distribution. An oak leaf phylloxeran, *Phylloxera* sp. nr. *glabra*, was collected on Salt Spring and Galiano islands, which is an extension of its previously known distribution at Victoria. Cherry bark tortrix, *Enarmonia formosa*, was found on cherry at Sidney, which was the first record of the insect outside the Fraser Valley; this is the only known area in Canada with this introduced tortrix. Yew big bud mite, *Cecidophyopsis psilaspis*, was collected at Victoria, Port Renfrew, and Nanaimo. This was the first collection of this insect for the Pacific Forestry Centre insectary.

Forest Insect and Disease Survey in the Pacific and Yukon Region

Who they are and what they do

The Forest Insect and Disease Survey (FIDS) is a nationally coordinated program of six regional FIDS units and the FIDS Technology Development Project. The program provides perspectives on insects and diseases including acid rain to forest managers, quarantine agencies, researchers, educators, and the public.

At the Pacific Forestry Centre, there are 18 positions within the FIDS organization headed by Dr. Allan Van Sickle. From May into October, 11 rangers work throughout six forest regions in British Columbia and in the Yukon Territory. Their regular reports are based on ground and aerial observations, egg counts, pheromone traps, plantation examinations, stand cruises, sketch maps, and other survey techniques. Most reports are supported by samples of the damaging agents.

Verification of the damaging agents is performed by Herbarium and Insectary staff. Collections which contain 26 000 disease specimens representing 3300 organisms and 66 000 insects representing 6000 different species, and their associated records, are essential for the correct identification of forest pests causing damage in the Pacific and Yukon Region.

A geographic information system enables analysis and presentation of insect or disease maps, in combination with major geographic boundaries, bio-geoclimatic zones and forest inventory and climatic information. This system was expanded during 1991 to improve its overlay capabilities and allow better links with other users. The system also links to a data retrieval and query system containing more than half a million insect and disease records from the region's forests.

Communication of information to operational forest managers is an important aspect of FIDS. To alert local managers and the public to new or threatening outbreaks, "Pest Reports" may be issued during the field season. In addition to this regional report, more detailed information for each provincial forest region is compiled and distributed. Contributions are also made to national forestry statistics and to a national report which outlines pest conditions in forests across Canada.

Forest insects and diseases will increasingly influence how forests are managed. Detailed measurements of losses for a range of pests and situations can be combined with survey results to improve statistics and to guide research and forest management. FIDS in the Pacific and Yukon Region is an integral part of the team required to solve major problems and reduce uncertainty in the complex, long-range management of forest crops.